# The Middle Triassic Megafossil Flora of the Basin Creek Formation, Nymboida Coal Measures, New South Wales, Australia. Part 3. Fern-like Foliage.

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Two quarries in the Basin Creek Formation of the Middle Triassic Nymboida Coal Measures have yielded numerous examples of fern-like foliage. No affiliated fertile material is available to place the fronds in a natural classification. Twenty three species in twelve genera are described as morpho-taxa in Order and Family Incertae Sedis. Plants described in this paper are:- *Cladophlebis conferta* sp. nov., *C. octonerva* sp. nov., *C. paucinerva* sp. nov., *C. retallackii* sp. nov., *C. sinuata* sp. nov., *C. tenuipinnula* sp. nov., *Dictyonymba sparnosa* gen. et sp. nov., *Gouldianum alethopteroides* gen. et sp. nov., *Leconama stachyophylla* gen. et sp. nov., *Micronymbopteris repens* gen. et sp. nov., *Nymbiella lacerata* gen. et sp. nov., *Nymboidiantum glossophyllum* (Tenison-Woods) gen. et comb. nov., *N. multilobatum* gen. et sp. nov., *N. elegans* gen. et sp. nov., *N. fractiflexum* gen. et sp. nov., *N. robustum* gen. et sp. nov., *Nymbophlebis polymorpha* gen. et sp. nov., *Nymbopteron dejerseyi* (Retallack) gen. et comb. nov., *N. foleyi* gen. et sp. nov., *N. uncinatum* gen. et sp. nov., *Nymborhipteris radiata* gen. et sp. nov., *Ptilotonymba curvinervia* gen. et sp. nov. and *Sphenopteris speciosa* sp. nov. The diversity of this new material demonstrates the remarkable recovery of Gondwana vegetation following the end-Permian extinction event.

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## INTRODUCTION

This paper is the third in a series describing the rich and diverse megafossil flora from two quarries near the village of Nymboida in north eastern New South Wales. A locality map and details of the geology of the Nymboida area were provided in Part 1 of this series (Holmes 2000) which dealt with the Thallophyta and Sphenophyta. Part 2 (Holmes 2001b) included descriptions of 14 taxa of the Filicophyta representing true ferns preserved in a fertile state or remains of sterile material with known fern relationships.

This paper describes fern-like foliage of uncertain systematic position due to the lack of fertile material. It is acknowledged that some at least of these fossil plants are not true ferns. They may be new forms of pteridosperms or even belong to plant groups that are presently unknown. Twenty four species are placed in twelve genera. The names published below are defined as morpho-taxa under the provisions of the International Code of Botanical Nomenclature (ICBN 2000).

The diversity of plants with fern-like foliage that are described below is a remarkable demonstration of the recovery of the world's vegetation following the end-Permian extinction event. That catastrophic and devastating event caused the disappearance of the Gondwana *Glossopteris* Flora and up to 90% of the world's living organisms. It brought about the cessation of all coal formation throughout the world. The "Coal Gap" (Retallack 1996) persisted until early Middle Triassic time. Some of the earliest coal seams following the "Coal Gap" are preserved in the Basin Creek Formation.

Included in this Middle Triassic coal flora are some specimens which in gross morphology are closely similar to ferns. Although some are common and widespread, none have been found with associated or identifiable fertile remains. Most of the morpho-taxa are rare and in some cases are based on a single specimen or just a few individuals. Even though specimens may be rare and fragmentary, provided there are significant diagnostic features for differentiation, they are illustrated and described in order to make

known their presence in the Nymboida Flora. The minimum criteria for formal naming are that the specimens demonstrate the attachment of pinnae to a main rachis and preferably with pinnules showing a reasonable state of preservation of the venation. Lebedev (1974) believed that through the use of good descriptions, accurate drawings and adequate photographs, sterile fern fronds could be confidently identified and even placed in natural groupings. In this paper I have attempted as far as possible to follow the guidelines of Lebedev. However, the novelty of most specimens, the lack of associated fertile material and the state of preservation precludes the placement of this material in a natural classification.

A tectonic heating event during the Cretaceous (Russell 1994) has destroyed the cuticle of otherwise often exquisitely preserved leaves and fruits of the entire flora at the two Nymboida localities. There is great scope for further investigations from localities where cuticle and fine cell structure may be preserved.

As in extant floras, the assemblages of fossil plants are directly related to their habitats. Several species of one genus may co-exist in a limited area but each within its own habitat. The presence of several species in the *Cladophlebis*, *Nymbopteron* and *Nymboidiantum* genera may relate to the taxa being derived from differing facies.

The sediments included in the 20 metres depth exposed in the working faces of the Nymboida quarries range from coarse conglomerates to fine shales and coal bands. Each horizon represents a flood event and a particular facies that existed through a short period of geological time (Holmes 2000) on an alluvial floodplain. Fossil soils formed during pauses in the deposition of sediments are also present The reconstruction of the Middle Triassic Nymboida floodplain by Retallack (1977) demonstrates the range of habitats that existed simultaneously. The fossil assemblages, supported by facies evidence, range from in-situ accumulations and fossil soils (autochthonous) to partially dispersed (semi-authochthonous) to long distance transport dispersal and fragmentation (allochthonous).

The origins and relationships of the majority of plants in the Early to Middle Triassic Gondwana floras are problematical. Due to the virtual spatial and climatic isolation of Gondwana and especially eastern Australia from the Northern Hemisphere following the end-Permian extinction event, I believe there is dubious value in attempting to determine close relationships between plants from those two macro-regions based only on gross morphology. This problem, relevant to sphenophytes, was discussed by Holmes (2001a). In this paper, with a few exceptions, I have compared the Nymboida fern-like foliage only with previously described Gondwana material. Where there is no published description matching my material I have erected new species and in some cases, new genera. These new taxa will provide a reference for comparisons with other Gondwana assemblages and, hopefully, will be the foundation for future studies based on better preserved and more complete material that will allow the fossil plants to be placed in a natural classification system. At that stage, more meaningful comparisons may be made with fossils from Triassic northern floras.

Most specimens are illustrated at both natural size and enlarged. The size of reproduction is indicated in the Figure legends and by a bar measure representing one centimetre on each photograph.

All the described, illustrated and mentioned specimens in this paper have been lodged with the Australian Museum, Sydney and have been catalogued with AMF numbers.

## SYSTEMATIC PALAEOBOTANY

Order Incertae sedis
Family Incertae sedis
Genus *Cladophlebis* Brongniart 1849
Type species *Cladophlebis albertsii* (Dunker) Brongniart 1849

The genus *Cladophlebis* was erected by Brongniart (1849) for sterile fern fronds from both the Late Palaeozoic and Mesozoic. It was generally regarded as a form genus. Fertile material has been placed variously in a number of natural genera. In an attempt to define *Cladophlebis* in a strict sense as a natural genus, Frenguelli (1947) carried out an extensive review of over 150 species and forms that had been attributed to *Cladophlebis*. On his restricted definition he recognised 28 Mesozoic species worldwide, including 14 species from the Triassic to Cretaceous in Argentina. Later Herbst (1971, 1978) revised both the Argentinean and Australasian species of *Cladophlebis*. For Australasia he retained as valid species the variable and long-ranging *Cladophlebis australis* with a synonymy list of 26 entries, and *C. mendozaensis*. *C. patagonica* and *C. gondwanica* were regarded as doubtful. However, the Nymboida Flora is rich in ferns and fern-like foliage and contains at least six species described below which are referable to this genus. In Part 2 of this series, fertile ferns were placed in *Asterotheca, Rhinipteris, Todites, Herbstopteris, Osmundopsis* and *Nymbofelicia* (Holmes 2001b). In most cases the associated sterile fronds would have fitted broadly in *Cladophlebis*.

Sterile fronds with no associated fertile material

are here placed in the morpho-genus *Cladophlebis* which includes bipinnate fronds, pinnules separated to the base, broadly attached to pinna rachis and variously decurrent, base occasionally slightly lobed either basiscopically or acroscopically, entire to slightly lobed or serrate, parallel-sided to slightly tapering, straight or variously falcate; midvein prominent and usually persistent almost to the apex, lateral veins alternate, forking once, twice or rarely three times, often simple distally. It must be understood that this is an artificial classification based merely on gross form and the individual morpho-taxa may belong in a range of natural genera.

*Cladophlebis conferta* Holmes sp. nov.
Figures 1A–C

**Diagnosis**

Medium sized bipinnate frond; pinnae closely spaced at high angle to main rachis; pinnules opposite to subopposite, broadly falcate, midvein fine, four pairs of lateral veins, proximal two pairs twice forked, second pair once forked, distal pair unforked or once forked close to margin.

**Description**

This taxon is based on two specimens each showing a midportion of bipinnate fronds that may have possibly reached one metre long in life. AMF121014 shows a main rachis tapering from 8 mm to 6 mm over a length of 300 mm. The holotype frond fragment (Fig. 1A) has a smooth main rachis 5 mm in width with seven pairs of overlapping opposite pinnae attached at c. 80° to main rachis at intervals of c. 10 mm. Pinnae linear, tapering in distal half to acute apex, to 100 mm long, 15 mm wide. Pinnules opposite to alternate, closely spaced to overlapping, to 8 mm long, 5 mm wide; length to width ratio of c. 1.6:1; attached at c. 45° at midpinna and at a higher angle closer to the main rachis; basiscopic margin decurrent, slightly contracted above base, margin broadly convex, acroscopic margin straight to slightly convex, apex obtuse; midvein fine, once forked before the pinnule apex; with four pairs of alternate lateral veins at c. 35° to midvein; first two pairs twice forked, second pair once forked and distal pair usually simple; forking very acute with c. 20 vein endings around pinnule margin (Fig. 1C).

**Holotype**

AMF120987, and portion of the counterpart as isotype AMF121015. Australian Museum, Sydney.

**Type locality**

Reserve Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF121014, Reserve Quarry, Nymboida.

**Name derivation**

*conferta – confertus*, (Lat.), *dense, crowded*, referring to the closely spaced pinnae and pinnules.

**Discussion**

Although known from only two specimens, the preservation is sufficient to provide diagnostic characters. *C. conferta* pinnules have a similar number of lateral veins as *C. octonervia* (described below), but differ by the shorter broader pinnules, the more acute and radiating form of the forking veins and by the fewer vein endings around the pinnule margin. By the closely spaced, long, opposite pinnae and by the form of the sparse and fine venation, *C. conferta* differs from all other Gondwana *Cladophlebis* spp.

*Cladophlebis octonerva* Holmes sp. nov.
Figures 2 A–C

1921 – *Cladophlebis mesozoica* var *typica* Kurtz pl. 30, Fig. 6.

**Diagnosis**

Medium sized bipinnate frond, pinnae opposite to alternate, pinnules thick-textured, alternate, oblong to triangular, entire or occasionally lobed, apex obtuse, median vein weak, continuing to apex, four pairs of lateral veins once forked close to midvein then diverging to margin.

**Description**

Complete fronds not available. The holotype (Fig. 2A), a 180 mm long midportion of a narrow elliptic bipinnate frond, suggests a total frond length of c. 400 mm. The main and pinna rachises are strongly ribbed and grooved. Pinnae opposite to alternate, attached basally at right angles or obtuse, in the middle of the frond at c. 80° to 90°, distally more acute; linear, longest in midportion of frond, to 60 mm long and 14 mm wide, tapering from midway to the acute apex. Pinnules alternate, oblong to triangular or straight to slightly falcate, attached at 90° to 60° to pinna rachis, basiscopic margin slightly contracted, acroscopic base slightly decurrent upwards, margin more convex on proximal side, entire to slightly lobed, apex obtuse, length to width ratio, c. 2–2.5:1. Midvein continuing to the apex, four pairs of lateral veins each once broadly forked close to the midvein; venules continuing to

diverge straight or slightly arching to the margin; number of lateral veins decreasing on smaller pinnules distally and apically. First lateral veins occasionally forking again near the margin (Fig. 2C). Number of vein endings around margin c. 16.

**Holotype**

AMF113484, Australian Museum, Sydney.

**Type locality**

Reserve Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF113485-86. Coal Mine Quarry, Nymboida.

**Name derivation**

*octonerva – octo*, (Lat.), *eight; nerva, (*Lat.*) veins*; referring to the usually four pairs of arching lateral veins in each pinnule.

**Discussion**

*C. octonerva* differs from other Nymboida *Cladophlebis* spp. by the shorter broader pinnules with four pairs of once-forking lateral veins in the pinnules. A frond fragment illustrated in Kurtz (1921, pl. 30, Fig. 6) from the Triassic of Argentina, as *C. mesozoica* var. *typica* has pinnule form and once-forking lateral venation closely similar to *C. octonerva.* Stipanicic et al. (1995), in a revision of the material figured in Kurtz (1921), followed both Frenguelli (1947, pl. 7, Figs 2,5) and Herbst (1971, Figs 17, 19), who defined *C. mesozoica* as having twice forked lateral veins. The *C. mesozoica* var *typica* specimen was not accepted as *C. mesozoica* and was merely identified as *C.* sp. By restricting *C. mesozoica* to leaves with twice forked lateral veins, forms such as *C. octonerva* and *C. sinuata* (described below), which are only partially twice forked, are excluded from that taxon.

*Cladophlebis paucinerva* Holmes sp. nov.
Figures 3A-G

**Diagnosis**

A small bipinnate frond with short narrow-ovate, opposite to alternate pinnae; pinnules alternate, broad-ovate, apex obtuse, length to width ratio of c. 2:1; midvein straight, dividing well before the apex, with two pairs of alternate lateral veins once-forking halfway to margin.

**Description**

This taxon is based on a number of small midportions of incomplete fronds to 35 mm long, which bear to five pairs of sub-opposite short pinnae; estimated total length of frond in life c. 50 mm. Rachis 1 mm wide, strongly ribbed and grooved; pinnae well-spaced, attached at c. 45°, narrow ovate to 15 mm long and 6 mm wide, tapering from halfway to the acute apex with c. 6 pairs of alternate pinnules. Pinnules broadly attached at c. 45°, decurrent basiscopically, slightly contracted acroscopically, broad-ovate, 3–4 mm long, 1.5–2 mm wide, becoming more triangular in midportion of pinna then coalescing apically; length to width ratio of c. 2:1; pinnule margin entire or slightly serrate; midvein straight or faintly undulate, forking well before the apex; two pairs of alternate lateral veins attached at a very acute angle, first pair once-forked halfway or closer to the margin, distal lateral veins simple (Fig.3A,D); six to eight vein endings around margin.

**Holotype**

AMF120979; isotype AMF120980, Australian Museum, Sydney.

**Type locality**

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF120981-120984.

**Name derivation**

*paucinerva – paucus*, (Lat.), *few; nervus* (Lat.), *nerve*, referring to the small number of lateral veins.

**Discussion**

Portions of two fronds are preserved on one small slab (Fig. 3C) but their appearance does not suggest that they are detached pinnae of a tripinnate frond. A pinna fragment from Argentina which was illustrated by Kurtz (1921, pl. 32, Fig. 11) as *Asplenium whitbyense* has small pinnules and venation similar to *Cladophlebis paucinerva.* Stipanicic et al. (1995) have reclassified that specimen as *Cladophlebis (Todites?) ugartei* Herbst 1964. As fertile fronds of *C. paucinerva* are not known, it is difficult to make a closer comparison with *C. ugartei. C. paucinerva* differs from all other known Gondwana Triassic *Cladophlebis* spp by its small size and the few lateral veins. The small creeping fern *Micronymbopteris repens* described below differs by the elongated pinnae and much smaller pinnules with no obvious venation. *C. parva* (Fontaine) Bell (1956), a Cretaceous fern from North America, has pinnules similar in size to *C. paucinerva* but differs by the tripinnate form and by the sometimes trilobed first basiscopic pinnules.

*Cladophlebis retallackii* Holmes sp. nov.
Figures 4A,B; 5A,B
1977 – *Cladophlebis gondwanica* non Frenguelli, Retallack in Retallack et al. p.86, Figs D-F.

**Diagnosis**

Medium to large bipinnate frond with robust primary rachis and opposite pinnae rachises. Pinnules opposite, straight to slightly falcate, slightly constricted above the basiscopically and acroscopically decurrent base, margins entire, parallel for c. half length then basiscopic margin curves apically to form acute to obtuse rounded apex. Median vein strongly decurrent, basal lateral veins attached to the primary rachis at the base of the midvein and thrice forked. Distally, lateral veins arch away from midvein, forking up to three times proximally, thence twice in mid-region and once apically.

**Description**

A robust bipinnate lanceolate frond with stout rounded primary rachis and pinnae rachises. In life possibly to one metre in length. Figure 4A is a portion of a large frond, primary rachis to c. 8 mm wide near broken lower section, base missing; pinnae opposite on lower portion of the frond, upwards becoming subopposite and then alternate apically, linear to 100 mm long and 20 mm wide, basal pinnae attached at right angles, becoming more acute, to 45° apically. Pinnules opposite to sub-opposite (Figs 4B, 5B), overlapping to well-separated, mostly oblong, straight to slightly falcate, slightly contracted in width above the decurrent base, attached at right angles close to primary rachis, becoming more acute distally, to 14 mm long and 5 mm wide, with length to width ratio of c. 2.5 (2–3.4):1. Midvein strongly decurrent on pinna rachis then decurving into pinnule and continuing almost to pinnule apex where it divides into two short veinlets. First basiscopic and acroscopic lateral veins attached at or just below the base of the median vein, basiscopic vein arching and forking three times to meet margin at a high angle, first acroscopic vein also branching three times with the adaxial vein running parallel to the pinna rachis. The subsequent five to seven pairs of lateral veins attached at c. 30° to midvein and arching to meet the pinnule margin at c. 45° to 60°, mostly twice forked then once forked near the pinnule apex, with c. 40–50 vein endings around the pinnule margin.

**Holotype**

AMF120959, Australian Museum, Sydney.

**Type locality**

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures. Middle Triassic.

**Other material**

UNEF133363-4, AMF120954-120959, 120993 and 121167, Coal Mine Quarry. The material from the Cloughers Creek Formation of the Nymboida Sub-Basin referred by Retallack (in Retallack et al. 1977), (see below), to *Cladophlebis gondwanica* and included here in *Cladophlebis retallackii* is also housed in the Australian Museum collections.

**Name derivation**

*retallackii* – for Dr G.J. Retallack who carried out research on the Nymboida Flora; pioneer investigator of fossil soils.

**Discussion**

Retallack (in Retallack et al. 1977) illustrated and briefly described fronds from the Cloughers Creek Formation of the Nymboida Coal Measures which he assigned to *Cladophlebis gondwanica* Frenguelli. Herbst (1978), with reservations, also included this material in *C. gondwanica*. Retallack noted that similar fronds also occurred in the Basin Creek Formation. This is confirmed by my collections, some of which are here illustrated and form the basis for the new taxon *C. retallackii*. The material selected by Frenguelli (1947) as the type for *C. gondwanica* was based on material from Tonkin in Vietnam that had earlier been identified by Zeiller (1903) with the European species *C. roessertii* (Presl) Krystofovich. The Tonkin material illustrated by Frenguelli (1947, Fig.19) has a similar length to width ratio as *C. retallackii* but differs by the more slender, canaliculated primary and pinnae rachises, by the alternate pinnules with straight lateral veins and fewer vein endings around the pinnule margins. Frenguelli included in *C. gondwanica* a frond from the Carnian Molteno Formation of South Africa which had been briefly described by Seward (1908, p.98, pl.8) and assigned to *C. (Todites) roessertii*. Seward's description and one illustration are lacking in details and I have not examined the specimen. From the illustration, the length to width ratio is lower and the pinnae are more acutely attached to the main rachis, so its affinity with *C. retallackii* is doubtful. With the exception of the material described by Retallack (in Retallack et al. 1977), there are no other records of fronds similar to *C. retallackii* in Triassic Gondwana floras.

*Cladophlebis sinuata* Holmes sp. nov.
Figures 6A-C
1921 – *Cladophlebis mesozoica* forma *typica* Kurtz pl. 32, Fig. 13
1921 – *Cladophlebis mesozoica* forma *crenulata*

Kurtz pl. 32, Fig. 14
?1982- *Cladophlebis mesozoica* Holmes p. 5, Fig. 3A

**Diagnosis**

Medium sized bipinnate frond; pinnae opposite, well-spaced, attached at a high angle. Pinnules alternate, elongate-triangular, closely spaced, margin irregularly dentate or lobed. Midvein fine, sinuate, forking near the apex, c. five pairs of lateral veins attached to median vein at c. 45°. First two pairs of veins twice forked, following veins once forked.

**Description**

*Cladophlebis sinuata* is based on seven specimens. The holotype (Fig. 6A) is a portion of a bipinnate frond showing three pairs of pinnae attached opposite at c. 90° to a conspicuously ribbed and grooved primary rachis 4.5 mm wide. The complete frond is estimated to have been c. 400 mm long. The pinnae are well separated, 45 mm and 35 mm apart, with a length perhaps of 150 mm. Pinnules sub-opposite to alternate, closely spaced to overlapping, broadly attached at c. 80° to ribbed pinna rachis, basiscopic margin contracted and acroscopic base expanded, elongate-triangular to slightly falcate, to 15 mm long and to 10 mm wide just above the base; length to width ratio of c. 1.6:1, becoming smaller and more acutely attached towards the pinna apex, margin broadly lobed or dentate, apex broadly acute to obtuse. Midvein fine, slightly undulate to sinuate, forking close to apex; four to five pairs of alternate secondary veins leave midvein at c. 45°; the proximal two pairs of veins fork twice, the distal two pairs fork once with the last one or two veins unforked (Fig. 6C); 18-24 vein endings around pinnule margin.

**Holotype**

AMF113512, Australian Museum, Sydney.

**Type locality**

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF113513-113518, AMF113541, Coalmine Quarry.

**Name derivation**

*sinuata – sinuatus*, (Lat.), *wavy* – referring to the course of the fine median vein.

**Discussion**

*Cladophlebis sinuata* is close to *C. wielandii* Jain and Delevoryas (1967) from the Carnian Cacheuta Formation of Argentina, but differs by the typically twice forked lateral veins in the basal portion of the pinnule lamina. Material from the Carnian Ipswich Basin, referred to *C. concinna* by Jones and de Jersey (1947, text Figs 4 and 5) has closely spaced pinnules with sinuous midveins. Their text fig. 4 differs from *C. sinuata* by the lateral veins which all fork twice, and text fig. 5 differs by the lateral veins which are all once forked in a manner similar to those referred to *C. concinna* by DuToit (1927) from the Carnian Molteno Formation of South Africa. *C. sinuata* is similar to some forms of the variable *C. mendozaensis* (Geinitz) Frenguelli 1947, Herbst (1971, Figs 13, 14 and 21) from the Upper Triassic of South America, but differs by the finer sinuous midrib, by the more closely spaced to overlapping pinnules and by the generally lower length to width ratio of the pinnules. The Upper Triassic Queensland material which was identified by Herbst as *C. mendozaensis* (Herbst 1978, pl 1, Figs 4 and 5, pl. 3, Figs 16-18) has alternate pinnae and a significantly higher length to width ratio. Specimens illustrated in Kurtz (1921, pl. 32, Figs 13, 14) as *C. mesozoica* forma *typica* and *C. mesozoica* forma *crenulata* have a sinuous midvein and similar lateral venation to *C. sinuata.* These two Carnian Cacheuta Formation specimens of Kurtz were placed by Stipanicic et al. (1995) in *C. mesozoica*, a taxon defined by its twice forking lateral veins, as discussed under *C. octonerva.* Frond fragments from the Middle Triassic Benolong Flora of central-western New South Wales which were placed in *C. mesozoica* by Holmes (1982) are similar in venation pattern and length to width ratio, but are of smaller size and have less vein endings around the pinnule margin. Another sterile pinna fragment from the same assemblage attributed to *Todites pattinsoniorum* Holmes (1982, Fig. 2D) also has similar venation to *C. sinuata*, thus suggesting that the latter could be the foliage of an osmundaceous fern.

*Cladophlebis tenuipinnula* Holmes sp. nov.
Figures 7A, 8 A-C

**Diagnosis**

Large tripinnate frond, tertiary pinnae alternate, linear; pinnules alternate, small, straight, closely spaced; lateral veins well-spaced and once forked.

**Description**

Large tripinnate frond (Fig.8A), primary rachis 35 mm wide near base which suggests a total frond length of from two to three metres. Secondary rachises (Fig. 7A) well separated, to 5 mm wide, straight, to 200 mm long. Secondary rachises in basal region obtuse, changing to right angles in mid-frond then slightly acute apically. Tertiary rachises at high angle

to secondary rachis, c. 10 mm apart, linear to 50 mm long, c. 10 mm wide. Pinnules alternate, attached by whole base, linear, straight to slightly curved, 4-5 mm long, 1-1.5 mm wide, length to width ratio of c. 4:1, closely spaced, free to base, margin entire, apex obtuse. Pinnule lamina apparently thick textured which obscures the venation. On some pinnules on AMF113526, which are preserved at an angle to the bedding plane (Fig. 8B), the venation is faintly evident and shows a fine midvein with c. 8 pairs of lateral veins attached at a high angle and once-forked close to the midvein; c. 30 vein endings around the margin. Fragmentary fertile pinnules appear to bear five or six pairs of *Asterotheca*-like synangia but the preservation is too poor to determine the structure.

**Holotype**

AMF113523; isotypes AMF113524-27, AMF113406, Australian Museum, Sydney.

**Type locality**

Reserve Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF121016-121018, Reserve Quarry.

**Name derivation**

*tenuipinnula – tenuis*, (Lat.), *long and slender*; referring to the attenuated pinnules.

**Discussion**

This is one of the largest fern fronds in the Nymboida Flora, but is known only from dispersed fronds on a single horizon. Some very fragmentary fertile material is available and while the preservation is very poor, the distribution and size of the sori on the pinnules appear to differ from all *Asterotheca* fronds previously described from Nymboida (Holmes 2001b). By the large frond size, by the very stout secondary rachises and by the very small densely spaced attenuated pecopteroid-like pinnules, *C. tenuipinnula* differs from all other Gondwana Triassic ferns.

? *Cladophlebis* sp. A
Figures 9 A-C

**Description**

Several frond fragments with characteristic narrow-elliptic pinnae with the first pinnules well detached from the main rachis, are here placed doubtfully in *Cladophlebis* due to lack of preserved venation. The available specimens indicate living fronds were from 80 mm to 150 mm long. The pinnae are opposite to sub-opposite, attached in lower portion of frond at c. 90° and becoming more acute (to 60°) apically. Pinnae elliptic to 35 mm long, with four to twelve opposite triangular to rhombic pinnules attached at c. 45° to 80°; pinnules separated proximally but soon coalescing and decreasing in size towards the acute apex; venation obscured by the obviously thick texture of the pinnules.

**Material**

AMF113508-113510, Coal Mine Quarry, Nymboida.

**Discussion**

The three specimens illustrated (Figs 9 A-C) show a range of variation but appear to represent intergrading forms. There are some similarities with foliage fragments of the seed ferns *Dicroidium* and *Lepidopteris*. However there is no indication that the fronds may have been forked as in *Dicroidium,* and the lack of pinnules on the main rachis precludes affinities with *Lepidopteris*.

*?Cladophlebis* sp. B
Figures 9 D, E

**Description**

An apical portion of a tiny bipinnate fern, 30 mm long, pinnae opposite, pinnules broadly attached and well-spaced, rounded, c. 2 mm in diameter. The venation is poorly preserved.

**Material**

AMF120978, Coal Mine Quarry, Nymboida.

**Discussion**

Only a single specimen of this tiny sterile fern frond has been collected. It is illustrated to draw attention to its presence. From the matching size and form, this could be a sterile frond affiliated with fertile *Todites parvum* described previously from Nymboida in Holmes (2001b).

? *Cladophlebis* sp. C
?1883 *Alethopteris currani* Tenison-Woods 1883 p. 77, pl. 6, Fig. 4
Figures 10A, B

**Description**

A small fragment of a pinnate (? bipinnate) frond shows eight pairs of well-spaced opposite decurrent elongate, slightly falcate pinnules with serrate margins, attached at c. 60° to a slender ribbed rachis; midvein decurrent, with four pairs of once-forked lateral veins attached at an acute angle to the midvein. Length to width ratio of c. 4:1.

**Material**

AMF120994, Coal Mine Quarry, Nymboida.

**Discussion**

? *Cladophlebis* sp. C has (?pinnae) pinnules somewhat similar in shape and venation to those of *Alethopteris currani* Tenison-Woods (1883) from the Middle Triassic Napperby Formation at Ballimore near Dubbo in central-western New South Wales, but differs by the wider spacing of the pinnules. The Ballimore and Nymboida specimens are too incomplete to warrant formal naming.

*Dictyonymba* Holmes gen. nov.
*Dictyonymba sparnosa* Holmes gen. et sp. nov.
Figures 10 C, D

**Combined diagnosis**

Bipinnate frond; pinnules broad ovate, conjoining, tapering to obtuse apex; lateral veins forking and occasionally joining to form coarse irregular reticulations in the conjoined area between the pinnules and towards the distal margin of each pinnule.

**Description**

*D. sparnosa* is described from a single fragmentary specimen showing portions of two parallel pinnae which bear partially conjoined pinnules with well-preserved venation (Fig. 10C). The size and form of the complete frond is not known. The larger pinna fragment is c. 39 mm long, bearing nine pairs of opposite pinnules attached at c. 60° to the pinna rachis, which tapers from 1 mm wide at the broken base. Pinnules broadly ovate but somewhat variable in shape, with convex entire margins, apices rounded, 5–6.5 mm long, 3.3–4.6 mm wide (Fig. 10D). Adjacent pinnules are conjoined for one third to one half of their length. Three to four pairs of once to three times forked lateral veins are attached at c. 45° to 60° to a slightly sinuous midvein. A separate vein enters the basiscopic portion of each pinnule lamina directly from the pinna rachis, forks three times and then meets in the conjoined region with some of the lateral veins from the adjacent pinnule to form an irregular mesh. In the distal free region of each pinnule where the lateral veins fork once or twice and sometimes anastomose, there are c. 18 vein endings around the margin.

**Holotype**

AMF113507. Australian Museum, Sydney.

**Type locality**

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Name derivation**

*Dictyonymba* - *dictyos*, (Gr.) *net*; referring to the net venation and the Nymboida locality.

*sparnos* - (Gr.) *scarce, rare*; recognising that one fragment only has been collected.

**Discussion**

*Dictyonymba* is a monotypic genus represented only by the type species *D. sparnosa*.

*Dunedoonia reticulata* Holmes (1977) is a pinnate fern-like frond with reticulate venation from the Late Permian of eastern Australia. *Dunedoonia reticulata* differs from *Dictyonymba sparnosa* by the basally contracted and much larger, broader pinnae and by the form of the anastomoses.

*Lonchopteris* and *Lonchopteridium* spp from the Carboniferous of Europe (Boureau 1975) and *Emplectopteris* Halle (1927) from the Permian of China are fern-like bipinnate fronds with varying forms of anastomosing venation. The form of the pinnules and venation pattern of *Dictyonymba sparnosa* differs in detail from any species described in the above genera. The differences in geographical distribution and time also strongly suggest that this Nymboida form is at least generically distinct. *Dictyonymba sparnosa* is unique in Gondwana Triassic floras.

*Gouldiopteris* Holmes gen. nov.
*Gouldiopteris alethopteroides* Holmes gen. et sp. nov.
Figures 11A-D

**Combined diagnosis**

An alethopteroid pinnatifid frond; pinna lobes with a distinct midrib, opposite, broad-linear, margin entire or slightly undulate, well-spaced, conjoined by a broad wing along primary rachis. Secondary veins closely spaced, arising directly from the main rachis and from the midvein in each pinna lobe at an acute angle (c. 45°), forking once, arching slightly then running parallel to wing and pinna lobe margins.

**Description**

This is a rare element in the Nymboida Flora. Only three specimens and their counterparts have been collected. The form and dimensions of complete fronds are not known. The holotype (Figs 11A, B) is a mid-section 55 mm long of a pinnatifid frond. Four pairs of opposite lobes are attached to the 3 mm wide primary rachis at c. 70° to 85°. The lobes are well-separated, c. 15 mm apart, broad-linear, 45 mm long and 10 mm wide, bases strongly decurrent to form a conjoining wing c. 2–3 mm wide along the main rachis, lobe margins straight or slightly undulate, apex broadly acute. A broad tapering midvein runs the length of

each lobe and forks close to the apex. Lateral veins from both the main rachis and midvein are attached at c. 45°, forking once, usually near the base, then arching slightly and running parallel to each other, reaching the wing or pinna margin at c. 45° to 80°. The density of veins along the pinna lobe margin is c. 20 per 10 mm.

AMF113563 (Fig.11D) is a 100 mm long section of a frond which in life may have reached 200 mm in length. The lobes, to 35 mm long and 6 to 8 mm wide, are attached at c. 40° to 50° to the primary rachis at a spacing closer than those of the holotype.

**Holotype**

AMF113561, Australian Museum, Sydney.

**Type locality**

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF113562, AMF112563, Coal Mine Quarry.

**Name derivation**

*Gouldiopteris* – *Gould*, for Dr R.E.Gould, former palaeobotanist at the University of New England, who encouraged my collecting and research of the Nymboida Flora; *pteris*, (Lat.), *fern.*

*alethopteroides* – *Alethopteris*, a Palaeozoic morpho-genus of fern-like fronds similar in gross morphology to the Nymboida material.

**Discussion**

*Gouldiopteris*, a monotypic genus with *G. alethopteroides* as the type species, is erected for foliage fragments that conform with the diagnosis of the Palaeozoic form genus *Alethopteris* Sternberg (Wagner 1968). *Alethopteris* is not a natural genus and includes both ferns and pteridosperms. Plants placed in the genus are common and widespread in the Carboniferous of the Northern Hemisphere, the Permo-Carboniferous of China and the Permian of Thailand. Boureau (1975) listed 96 species, varieties and synonyms. Because of the vast time and geographical differences between Northern Hemisphere plants that have been placed in *Alethopteris* and the Nymboida material, it is highly improbable that there is any close relationship. I have erected the new morpho-genus *Gouldiopteris* to avoid suggestions that *Alethopteris* had Mesozoic representatives and a cosmopolitan distribution.

Most early records of *Alethopteris* species in Australia have subsequently been revised or were based on unidentifiable material. *Alethopteris australis* (Morris) Johnston (1888), Feistmantel (1890) and *Alethopteris serratifolia* Johnston (1887) from Tasmania in which the pinnules are separated to the base, were placed in *Cladophlebis australis* (Morris) by Walkom (1926). Specimens from the Upper Triassic of Queensland, originally placed in *Alethopteris lindleyana* (Etheridge Jnr 1892) and ?*Alethopteris lindleyana* (Shirley 1898), were removed by Walkom (1917) to *Cladophlebis royalei*, a species which was described from the Permian of India (Arber 1905). All the above specimens previously placed in *Alethopteris* are bipinnate and do not conform with the diagnoses of *Alethopteris* or *Gouldiopteris.*

*Dejerseyia lobata* (Jones and de Jersey) Herbst 1977 has simple to pinnatifid leaves with elongate lobes as in *Gouldiopteris alethopteroides* (see also *Dejerseyia lobata* 'forma D' of Anderson and Anderson 1983), but differs from *G. alethopteroides* by the lateral venation of well spaced decurrent secondary veins which arch and divide several times. *Dejerseyia lobata* is now considered to be a gymnosperm (Anderson and Anderson, in press). The form of *Gouldiopteris alethopteroides* is unique in Gondwana Triassic floras.

*Leconama* Holmes gen. nov.
*Leconama stachyphylla* Holmes gen. et sp. nov.
Figures 12A-C

1975 *Cladophlebis lobifolia* non (Phillips) Seward, Flint and Gould, pl.1, Fig. 6 only
1977 *Lobifolia dejerseyi* Retallack (in Retallack et al.) pp 88-89

**Combined diagnosis**

Medium sized bipinnate frond; pinnae opposite, pinnules broad falcate, basiscopic margin sub-circular, acroscopic margin straight to slightly concave; midvein decurrent, weak, soon dissolving into several radiating and forking venules.

**Description**

This taxon is based on single pinnae (Fig. 12B, C and Flint and Gould 1975, pl.1, fig 6) and a frond fragment showing linear opposite pinnae attached acutely to a slender main rachis (Fig. 12A). Pinnae opposite, linear to 100 mm long; pinnules opposite, closely spaced to overlapping, free to the base, attached at c. 60°, broad falcate, entire, c. 6 mm long and wide; basiscopic margin sub-circular convex through c. 90°; acroscopic margin decurrent upwards at base then straight or slightly concave at an obtuse angle to the rachis; apex rounded-acute. A decurrent weak midvein arches into each pinnule from near the basiscopic margin, giving off two pairs of closely spaced lateral veins then dissolving into forking and radiating

venules. First one or two basiscopic lateral veins forking twice to three times; first acroscopic lateral vein forking three times with the near venule running parallel to the pinna rachis; following lateral veins once forked or simple, radiating, c. 24 to 28 vein endings around margin.

**Holotype**

AMF121183, Australiam Museum, Sydney. (Formerly UNEF14124).

**Type locality**

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF121160 formerly UNEF 14104, AMF113544 and its counterpart.

**Name derivation**

*Leconama – lekos*, (Gr.), *basin*, *nama*, (Gr.), *stream*, referring to the type locality in the Basin Creek Formation.

*stachyophylla – stachys*, (Gr.), *ear of grain; phyllon*, (Gr.), *leaf*, referring to the leaf outline resembling an ear of wheat.

**Discussion**

*Leconama* is a monotypic genus with *L. stachyophylla* as the type species. A pinna fragment of *L. stachyophylla*, previously illustrated by Flint and Gould 1975, pl. 1, fig. 6, and referred to *Cladophlebis lobifolia*, was included by Retallack (in Retallack et al. 1977) in *Lobifolia dejerseyi*, now *Nymbopteron dejerseyi* Holmes (see below). *Leconama stachyophylla* differs from *Nymbopteron* species by the absence of the conjoining of the first acroscopic pinnule to the main rachis. The pinnule shape and venation pattern distinguishes *L. stachyophylla* from all other described Gondwana Triassic fronds.

*Micronymbopteris* Holmes gen. nov.
*Micronymbopteris repens* Holmes gen. et sp. nov.
Figures 13, 14A-D

**Combined diagnosis**

A small procumbent or climbing plant with elliptic to lanceolate bipinnate fronds to 70 mm long, irregularly spaced along a curved tapering rhizotomous stem. Pinnae alternate, linear, bearing oblong, thick-textured pecopteroid pinnules.

**Description**

The holotype (Figs 13A, 14A) shows portions of five elliptic bipinnate fronds attached spirally and irregularly to an elongated tapering stem or rhizome. At the broken base the width is 5 mm and tapers through a length of 85 mm to 2 mm wide. Another specimen (Fig. 14B) was retrieved from the same fractured block. I believe that it is the lower portion of the holotype but the section of the stem that would join the two is missing. The lower stem fragment is 12 mm wide with one frond attached at right angles then decurving vertically. The holotype shows an almost complete frond and another four acutely attached incomplete fronds as well as detached fragments nearby. The complete frond is acutely decurrent, bipinnate, elliptic to 70 mm long, c. 35 mm wide; main rachis robust, tapering from 25 mm wide at base; pinnae c. 4 mm apart, with thick rachises, opposite, becoming subopposite to alternate apically, to 30 mm long and 3 mm wide, mostly linear but tapering close to the base and towards apex; pinnules alternate, closely spaced, free to the base, attached at c. 80° to 60°, oblong with rounded apex, c. 1–1.5 mm long, c. 0.5–0.75 mm wide, length to width ratio of c. 2:1; venation obscured by the apparent very thick texture of the pinnule lamina.

**Holotype**

AMF120962, isotype AMF120963, Australian Museum, Sydney.

**Type locality**

Reserve Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF120964–120966.

**Name derivation**

*Micronymbopteris* – contrived, for *small Nymboida fern.*

*repens* – (Lat.), *creeping*, for the inferred growth form.

**Discussion**

*Micronymbopteris* is a monotypic genus with the type species *M. repens*. Most ferns and fern-like taxa in the fossil record are known only from detached fronds, many of which are incomplete or even fragmentary. The holotype of *M. repens* is a rare and important find as it demonstrates the elongated stem and probable creeping or climbing growth form of the once living plant.

*M. repens* is unlike any other described fern-like material and its fronds are perhaps the smallest in the Gondwana Triassic fossil record.

*Nymbiella* Holmes gen. nov.
*Nymbiella lacerata* Holmes gen. et sp. nov.
Figures 15A, 16A, B

**Combined diagnosis**

Medium to large bipinnate-bipinnatifid frond; pinnae opposite to subopposite, broad linear; pinnules irregular in width and shape, separated to base or conjoined; apices obtuse, lobed or irregularly lacerated. First basiscopic pinnules sometimes attached to the main rachis. Venation odontopteroid, from one to three or more veins arching from pinna rachis into each pinnule, dividing once, occasionally twice and running parallel to each other to the distal margin.

**Description**

Medium to large bipinnate-bipinnatifid fronds estimated to reach 600 mm in length and 220 mm in width. No fronds are complete and no bases are present. The holotype (Fig. 15A) is an apical portion of a frond 220 mm long with another frond adjacent and slightly diverging. There is no evidence that the two fragments may be pinnae of a tripinnate fern. The main rachis in the base of this specimen is 3 mm wide and tapers gradually apically. In the length preserved there are 13 pairs of opposite to subopposite pinnae attached at 12–15 mm apart. The pinnae have a decurrent base then continue straight for their whole length at an angle of 60° to 75° to the main rachis. Pinnae broad-linear to 120 mm long and 20 mm wide, tapering in distal quarter to an acute apex. Pinnules of irregular shape and width, 8–10 mm long, attached from 60° to 80°, usually parallel-sided, sometimes contracted at the base (Fig.16A), sometimes several pinnules conjoined (Fig. 16B), apices obtuse, flattened or variously lobed or lacerated. Basal basiscopic pinnules attached around the junction of the pinna rachis with the main rachis and sometimes directly to the main rachis. The pinnule lamina is apparently thin with the venation clearly defined. Venation odontopteroid; one to three or more veins arching into each pinnule, forking once or occasionally twice and running straight and parallel to each other to the distal margin.

**Holotype**

AMF113530, Australian Museum, Sydney.

**Type locality**

Reserve Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF113531, 113536, 121174 from Reserve Quarry. AMF113532, 113535, 113537, 121173 from Coal Mine Quarry.

**Name derivation**

*Nymbiella* – contrived from *Nymboida*, the source of the material.

*lacerata* – (Lat.) *lacerated, irregularly torn*; referring to the apical margin of many pinnules.

**Discussion**

*Nymbiella* is a monotypic genus with *N. lacerata* as the type species. Over forty specimens are in the collections, all are incomplete and none show the basal region. The extreme variability of pinnule shape and form of *N. lacerata* is unique in Gondwana fern-like fronds. The two frond fragments on the holotype slab appear to be arising from a common base, and suggest a growth form perhaps similar to that of *Osmundopsis scalaris* (Holmes 2001b).

*Odontopteris? (Callipteris) laceratifolia* from the Upper Palaeozoic of China, illustrated by Halle (1927 pl. 32, figs 1, 2) has bipinnatifid leaves with lacerated margins and odontopteroid venation. However Halle's material differs from *Nymbiella lacerata* by the less divided pinnae and by the veins at a more acute angle. Because of the geographic and time differences I believe that *N. lacerata* should be regarded as generically distinct.

*Nymboidiantum* Holmes gen. nov.
Type species *Sphenopteris (? )glossophylla* Tenison-Woods 1883 p. 58, pl. 4, fig. 4

**Diagnosis**

Fern-like foliage; fronds bipinnate or rarely pinnate; pinnules attached at c. 45°, contracted at the base, sessile, lamina elliptic, margin entire, lobed or divided into segments. Three veins enter pinnule base, each forking one or more times as they pass into the lobes or distal portion of the entire lamina.

**Discussion**

From the gross morphology of pinnules with contracted bases and radiating venation, *Nymboidiantum* resembles the sterile fronds of some extant species of the fern genus *Adiantum* but no close relationship is inferred. Fossil leaves of Palaeozoic age with somewhat similar morphology have been placed variously in the genera *Triphyllopteris* (Boureau 1975; Morris 1975), *Adiantites* (Boureau 1975), *Genselia* (Knaus and Gillespie 2001), *Palmatopteris* (Boureau 1975) and *Archaeopteris* (Feistmantel 1890; Boureau 1970). Others of Late Jurassic to Tertiary age from the Northern Hemisphere have been placed in *Adiantopteris* (Boureau 1975). Because of the vast differences in time and distance, the new genus *Nymboidiantum* is erected to separate the Nymboida

material from the genera listed above. Undescribed *Nymboidiantum* foliage from the Carnian Molteno Formation of South Africa has been figured by Anderson and Anderson (1983, pl. 9; Figs 1a, 1b) as 'Incertae sedis gen. A, sp. A'. All the specimens from Nymboida here placed in *Nymboidiantum* are known only from sterile fronds, so their natural affinities are not known. With the exception of *Nymboidiantum glossophyllum* which is known from c. 40 specimens, the other taxa are very rare. I have distinguished five species mainly on the size, form and placement of the pinnules, and there appear to be no intergrading forms. The different fossil species are each preserved in sediments representing specific facies and it may be reasonable to assume that in life they grew in different habitats.

*Nymboidiantum glossophyllum* (Tenison-Woods 1883) Holmes gen. et comb. nov.
Figures 17A-E, 18C, D

1883 *Sphenopteris (?) glossophylla* Tennison-Woods p.58, pl.4, Fig.4
1983 Incertae sedis foliage gen. A, sp. A Anderson and Anderson, pl.9, Figs 1a and 1b.

**Diagnosis emended**

Medium sized bipinnate frond; pinnules well-spaced, alternate, elliptic with contracted decurrent base; proximal pinnules sometimes tri-lobed to deeply incised; venation sparse, forking and radiating to apical margin.

**Description**

The type specimen of Tenison-Woods (1883) is a small fragment showing three pairs of incomplete pinnae attached alternately to a main rachis that is mostly missing in the coarse siltstone matrix (refigured here, Fig. 17A). The elliptic pinnules are closely similar to those on many specimens in the Nymboida collections. However the Nymboida material exhibits a range of variation amongst specimens that I include in this species, especially in the lobing of the proximal pinnules. AMF120946 is a siltstone slab with some almost complete ovate fronds to c. 250 mm long (Fig. 17C), with alternate pinnae bearing to eight pairs of sub-opposite to alternate elliptic pinnules. The pinnules are from 5-10 mm long and 3-5 mm wide, attached at c. 45°-60° to the pinna rachis. Basally the shorter pinnae are at right angles to the main rachis becoming acute apically. Proximal pinnules are sometimes partially divided into two or three lobes (Figs 17B, D, E). On some specimens (Figs 18C, D) the pinnules are divided to the base into three linear lobes. The texture of the pinnule laminae appears to be thick and the venation is rarely observed, except in some rare types of preservation where sparse radiating veins may be faintly visible.

**Lectotype**

AMF68449, Australian Museum, Sydney. Formerly catalogued as SUF35 in the fossil collections of Sydney University.

**Type locality**

"Talbragar Mines" of Tenison-Woods (1883). Probably north-east of the present day village of Ballimore on the Talbragar River east of Dubbo, in the Napperby Formation, Middle Triassic.

**Other material**

AMF121158–121149, 121152, Coal Mine Quarry, AMF121150, 121153, Reserve Quarry.

**Discussion**

I have examined the specimen of *Sphenopteris (?) glossophylla* Tenison-Woods which is now housed in the Australian Museum, Sydney. It is a small fragment of a pinna rachis with ?alternate ovate pinnules with contracted bases and no visible venation. It agrees well with much of the Nymboida material, which, however, demonstrates a wide range of variation. The emended diagnosis reflects the diversity present in the Nymboida specimens which I now include in this taxon. The type locality, 'Talbragar Mines' near Ballimore on the Talbragar River, is in a very poorly collected area of the Middle Triassic Napperby Formation (previously included in the Wallangarra Formation, Cameron et al. 1999), which outcrops along the south-eastern margin of the Great Artesian Basin in central-western New South Wales. An assemblage of fossil plants from the same formation at Benolong, south west of Dubbo, has been described by Holmes (1982, 2001a).

In gross morphology *N. glossophyllum* is closely similar to some forms of *Triphyllopteris* known from the Carboniferous of Peru and the Northern Hemisphere (Boureau 1975, Figs 557, 558), but these forms are regarded as distinct due to the geographic and time differences.

Comparisons between *Nymboidiantum glossophyllum* and those species described below are given under the respective species.

*Nymboidiantum multilobatum* Holmes gen. et sp. nov.
Figures 18A, B

**Diagnosis**

Medium sized bipinnate frond, pinnae sub-opposite; pinnules broad-flabellate, divided into

several more or less deeply incised lobes.

**Description**

Frond bipinnate, estimated length to c. 250 mm; main rachis 4 mm wide near base, tapering gradually, apical portion of frond not preserved. Pinnae sub-opposite, 30 mm wide, length not known. Pinnules alternate attached by contracted base at c. 45° to pinna rachis, rhombic to sub-circular, 15 mm long and wide near main rachis, decreasing in size distally. Pinnules deeply divided into three to five segments, each segment with two or three elongated, obtuse lobes. A single vein enters each pinnule, soon forking into each segment and again into each lobe.

**Holotype**

AMF113558; isotypes AMF113559, 113560, Australian Museum, Sydney.

**Type locality**

Reserve Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Name derivation**

*multi*, (Lat.) *many*; *lobata,* (Lat.) *lobed*; referring to the much dissected pinnules

**Discussion**

This morphotaxon is known only from a single incomplete specimen that is associated with large *Sphenobaiera* leaves. It differs from all other species of *Nymboidiantum* by the larger flabellate pinnules which are divided into several segments, each segment with apical lobes.

*Nymboidiantum elegans* Holmes gen. et sp. nov.
Figures 19A, B

**Diagnosis**

Pinnae alternate, linear; pinnules well-spaced, opposite, elliptic, not lobed. First basiscopic pinnule attached in angle between the main and pinna rachis or directly on the main rachis.

**Description**

The holotype (Fig.19A) is an apical fragment, 130 mm long, of a frond which in life was probably twice that length. Width of the main rachis at the base of the portion preserved is 2.5 mm, tapering gradually to the apex. Main rachis longitudinally striated but not conspicuously ribbed or grooved. Pinnae alternate, decurrently attached at c. 45° to the main rachis, linear, 15 mm wide, to 65 mm long, tapering in the distal portion to an acute apex. Pinnules opposite, evenly spaced, symmetrically elliptical, entire, apex acute, c. 8 mm long and 3 mm wide, well separated, decreasing in size distally and apically, 12 pinnules in a pinna length of 60 mm. The first basiscopic pinnule on each pinna is attached at the base of the pinna rachis or directly to the main rachis. Towards the frond apex the pinnules coalesce to form lobed or entire pinnae. Venation not preserved.

**Holotype**

AMF113504; isotype AMF113505.

**Type locality**

Reserve Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF113506, Coal Mine Quarry.

**Name derivation**

*elegans* – (Lat.), *elegant*; referring to the neat and even spacing of the pinnules.

**Discussion**

*N. elegans* differs from *N. glossophyllum*, *N. robustum* and *N. multilobatum* by the opposite, elliptic, well-spaced pinnules and by the absence of lobing of the proximal pinnules.

*Nymboidiantum fractiflexum* Holmes gen. et sp. nov.
Figures 19C, D

**Diagnosis**

Planate, pinnate frond; rachis flattened, grooved, changing direction slightly at each pair of opposite pinnae. Pinnae sessile, rhombic, venation fine, forking and radiating from a short midvein.

**Description**

This taxon is based on a single specimen which consists of five pairs of opposite pinnae on a slightly zigzag rachis in which the rachis and pinnae appear to be flattened in one plane (Fig. 19C). The rachis as preserved is 50 mm long, with a conspicuous medial groove and longitudinal striations, 2 mm in width near base and not visibly decreasing to the tip, where it forms a short broken projection beyond the last pair of pinnae. Pinnae well-spaced c. 12 mm apart, decurrent on rachis, sessile, attached at c. 45°, c. 35 mm long and 10 mm wide, obtrullate to rhombic, entire with acute apex. Fine lateral veins diverge from a midvein or groove in the proximal one third of the pinna and fork several times distally. In the proximal half of the pinna, the radiating veins run parallel to the

margin. In the distal half, the veins terminate along the margin with a density of c. 12 per 10 mm (Fig. 19D).

**Holotype**

AMF113502, Australian Museum, Sydney.

**Type locality**

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Name derivation**

*fractiflexus* – (Lat.) – *deviating from side to side, zigzag*, as in the rachis of this taxon.

**Discussion**

By its pinnule shape and venation this leaf fragment is placed in the morpho-genus *Nymboidiantum,* but by the flattened zigzag rachis and pinnate form it differs from all other described species. The type specimen of *N. fractiflexus* may be a pinna of a large bipinnate frond as in other *Nymboidiantum* species.

*Nymboidiantum robustum* Holmes gen. et sp. nov.
Figures 20A-C

**Diagnosis**

Pinnules broad, ovate, opposite, well-separated proximally, coalescing distally; first acroscopic pinnule broadly but shallowly lobed.

**Description**

Medium to large bipinnate frond; midportions only of fronds preserved. Complete fronds estimated to exceed 300 mm long. The main rachis of the holotype (Fig. 20B) decreases in width from 2.5 mm to 2 mm over a length of 125 mm. Pinnae opposite to subopposite, broad-linear, 15 mm wide, 40-50 mm long. Pinnules opposite, attached at c. 45°, base slightly contracted, strongly decurrent, well separated proximally, coalescing distally, 4-8 mm wide, 5-12 mm long, margins entire, apex obtuse. First acroscopic pinnule shallowly lobed. The venation is not clear but three veins appear to enter base with each vein forking once.

**Holotype**

AMF113496, Australian Museum, Sydney.

**Type locality**

Reserve Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF113495, 113497, 121164, 121166, all Reserve Quarry.

**Name derivation**

*robusta* – (Lat.), *robust*, referring to the broad compact pinnules.

**Discussion**

*N. robustum* differs from all other *Nymboidiantum* species by the larger pinnules with broadly decurrent bases.

*Nymbophlebis* Holmes gen. nov.

*Nymbophlebis polymorpha* Holmes gen. et sp. nov.
Figures 21A, 22A-C, 23A-C

**Combined diagnosis**

Large polymorphic frond with long opposite linear, slightly arching primary pinnae distally bearing cladophleboid pinnules; in basal and proximal portions of fronds, primary pinnae tripinnate with fine pinnules; distally pinnae becoming bipinnate to pinnate as ultimate segments coalesce and conjoin to form large linear entire pinnules.

**Description**

This taxon is based on large bi-tri-quadripinnate sterile fronds in which the polymorphic characters may occur on a single primary rachis. Figure 20 is a basal portion of a frond estimated to have reached 1 m long. Secondary rachises opposite, slightly arching or straight, to 150 mm long, 20–30 mm wide with 20 to 30 alternate pinnae-pinnules; proximal portions of the lower rachises often tripinnate to bipinnate but pinnules distally conjoining to progressively coalesce until the primary rachis is simply pinnate (Figs 22. A, B; Figs 23A-C). The cladophleboid distal and apical pinnules are attached by a wide base, slightly contracted basiscopically and enlarged or decurrent upwards on the acroscopic side; broad-linear or slightly tapering, margin entire or slightly lobed close to the tripinnate segments of the frond, 12–18 mm long, 3-5 mm wide, with length to width ratio of c. 3.5–4:1; midvein decurrent, strong, persisting almost to pinnule apex; 8–10 pairs of lateral veins; first basiscopic lateral vein attached in angle between the pinna rachis and midvein, forking twice with proximal venule forking again; other lateral veins decurrent, all twice forked; first dichotomy close to the midvein then again at 1/3 the distance to the margin; venules travelling straight, close and parallel to meet margin at c. 45° to 70°.

**Holotype**

AMF120995, Australian Museum, Sydney.

**Type locality**

Reserve Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF120988, 120996-121007, 121009-121013, Reserve Quarry; AMF121008, Coal Mine Quarry.

**Name derivation**

*Nymbophlebis* contrived, for *Cladophlebis*-like plant from Nymboida.

*polymorpha* – (Gr.) *many forms*, referring to the diversity of pinnule shapes within a single frond.

**Discussion**

*Nymbophlebis* is a monotypic genus with *N. polymorpha* as the type species. Almost complete fronds of *Nymbophlebis polymorpha* occur at the Reserve Quarry in a bed of olive-grey mudstone. Reliable identification can only be achieved from substantially complete fronds. Retallack (1977) listed frond fragments from the Coal Mine Quarry at Nymboida which agreed well with the the bipinnate portions of *Nymbophlebis polymorpha* as '*C. australis* sensu stricta Morris with twice forked lateral veins'.

The interpretation of *Pecopteris australis* Morris (1845) [= *Cladophlebis australis* (Morris) Walkom (1917)] from the Triassic Newtown Beds of Tasmania has had a long and confused history. The pinnules in the bipinnate portions of *Nymbophlebis polymorpha* are similar in shape to those of Morris's fronds and the lateral veins are twice forking. However, *N. polymorpha* differs in that the primary and secondary forking of the lateral veins occurs close to the midvein and the veins then proceed close and parallel to each other to the margin, in contrast to those of Morris's illustration which fork midway to the margin and then widely diverge.

The polymorphic nature of the complete fronds of *Nymbophlebis polymorpha* argues for their placement in a genus separate to *Cladophlebis*. Isolated bipinnate fragments may be best placed in *Cladophlebis* sp. indet.

The diverse form of the pinnules of *N. polymorpha* is reflected in some forms of the extant genera *Pteris* and *Pteridium*, but no relationship is inferred.

*Nymbopteron* Holmes gen. nov.
Type species *Lobifolia dejerseyi* Retallack (in Retallack et al. 1977)

**Diagnosis**

Small to large bipinnate-bipinnatifid fronds, the first acroscopic pinnule of each pinna always confluent between the pinna and main rachises to form a triangular wing. First basiscopic pinnule sometimes enlarged, triangular, rectangular, rounded or variously lobed, often attached between pinna and main rachis or directly to the main rachis; subsequent cladophleboid pinnules of even size and shape for most of the pinna length but decreasing in size and conjoining distally and apically.

**Name derivation**

*Nymbopteron – nymbo;* referring to Nymboida, the source of the material; *pteron*, (Gr.), *wing*; referring to the winged shape of the first acroscopic pinnules.

**Discussion**

The genus *Nymbopteron* is erected to include Australian material formerly placed in *Cladophlebis lobifolia* (Flint and Gould 1975), *Lobifolia dejerseyi* Retallack (in Retallack et al. 1977) and possibly *Cladophlebis lobifolia* (Walkom 1924, 1928). *Cladophlebis lobifolia* sensu stricta is a Northern Hemisphere species, having been recorded from the Middle Jurassic to Early Cretaceous of Europe, Russia and China. Fertile specimens are placed in *Eboracea lobifolia* Thomas (Harris 1961). *Lobifolia,* a genus with a new type, *Lobifolia novopokrovskii* was erected by Lebedev and Rasskazova (1968) who also included the combination *Lobifolia lobifolia*, contrary to ICBN rules (as discussed by Rigby 1977). Retallack (in Retallack et al. 1977) described the new species *Lobifolia dejerseyi* and illustrated a small fragment from the Cloughers Creek Formation (Retallack et al. 1977, Fig.5A). He selected as the holotype a specimen from the Basin Creek Formation that had been assigned to *Cladophlebis lobifolia* by Flint and Gould (1975 Pl.1, fig.4). That specimen is reillustrated here as Fig. 25A. Apart from the geographical and time differences, the Nymboida material described by Retallack and the additional new species described below differ significantly from both the Northern Hemisphere *Lobifolia* species and *Cladophlebis* sensu Frenguelli (1947) by the placement and form of the first basiscopic and acroscopic pinnules. It is essential when identifying fossils as *Nymbopteron* that the material includes the portions of the pinnae attached to the main rachis. Isolated distal pinna fragments may be confused with *Cladophlebis* or *Dicroidium* species.

Four species of *Nymbopteron* are described below. They are distinguished by the frond size, shape and venation of the pinnules and particularly by the shape and position of the first basiscopic pinnules.

While the collected material of some of these species is limited, each species occurs in a sediment type representing a different facies similarly to that noted for *Nymboidiantum* spp. above, and it is most probable that each species grew in a different vegetation type. In the present collection there are no intergrading forms between the species.

*Nymbopteron dejerseyi* (Retallack, in Retallack et al. 1977) Holmes gen. et comb. nov.
Figures 24A–E and 25A

1975 *Cladophlebis lobifolia* non (Phillips) Seward, Flint and Gould, pl.1, Fig.4 only
1977 *Lobifolia dejerseyi* Retallack in Retallack et al., p.88

**Emended diagnosis**

Medium sized ovate fronds; first basiscopic pinnule enlarged and of irregular shape, attached in angle between pinna rachis and main rachis or directly on main rachis; venation radiating and forking; following pinnules with midvein persisting almost to apex, first basiscopic vein attached at base of midvein or directly to pinna rachis, lateral veins twice or once broadly forked.

**Description**

Retallack's holotype, reillustrated here as Fig. 25A, is a midportion of a broad ovate frond estimated to have been up to c. 200 mm long. No complete fronds are available. The main rachis is deeply grooved and ridged (Figs 24A-D), 2–3 mm wide near base. Pinnae well separated, sub-opposite to alternate, basal pinnae short and obtuse with conjoined pinnules (Fig. 24B); in mid-frond, pinnae attached at a right angles and pinnules separated to the base, apically the pinnae becoming moderately acute and pinnules again coalescing (Fig. 24C). First basiscopic pinnule enlarged and of irregular shape, attached in angle between pinna and main rachis or directly to main rachis (Figs 24D, E) in the manner of zwischenfiedern as in *Lepidopteris* species (Anderson and Anderson 1989); with strong midvein at centre base of pinnule, forking into three major lateral veins with each vein again forking once to three times, 8 to 28 vein endings around the margin. The venation in the triangular first acroscopic pinnule bifurcates three times, distal veins almost parallel. The succeding pinnules opposite to alternate, free to the base but closely spaced, ovate to broad-falcate, 4–10 mm long and 2–4 mm wide, length to width ratio of c. 1.6–2:1; midvein slightly sinuous, persistent almost to apex, three to four pairs of alternate lateral veins broadly forking once or twice, first lateral vein sometimes arising directly from the pinna rachis.

**Holotype**

AMF121158 (formerly UNEF14102), Australian Museum, Sydney.

**Type locality**

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF113543-113557, 120972, 120974, 120975, Coal Mine Quarry; AMF120973, 120977, Reserve Quarry.

**Discussion**

The holotype of this species was placed by Retallack (in Retallack et al. 1977) in the genus *Lobifolia,* which is essentially a Northern Hemisphere genus of Jurassic to Cretaceous age (Lebedev and Rasskazova 1968; Boureau 1975) as discussed above. The conjoining of the first acroscopic pinnules to form a decurrent triangular membrane between the base of the pinna rachis and the main rachis does not occur in *Lobifolia* but is diagnostic for *Nymbopteron.*

*N. dejerseyi* differs from the other *Nymbopteron* species by the broadly enlarged basal basiscopic pinnules with radiating venation and by the persistent midvein with broadly forking lateral veins in the following pinnules.

*Nymbopteron foleyi* Holmes gen. et sp. nov.
Figure 25B, C; 26A

**Diagnosis**

Small to medium sized fronds, first basiscopic pinnules rounded, attached along base of pinna rachis; following pinnules triangular-falcate; midvein weak, forking four or five times into fine radiating venules.

**Description**

Several almost complete broad elliptic to ovate fronds on AMF113538 (Fig. 26A) are up to 150 mm long and 65 mm wide; main rachis 2 mm wide near base. Pinnae opposite to alternate, basal pinnae short, with decurved attachment, at high angles in mid frond and becoming more acute apically. First basiscopic pinnules attached near the base of the pinnae, semicircular; first acroscopic pinnule enlarged, triangular and conjoined in the angle between the main rachis and the pinna rachis and reaching almost to the next pinna rachis; following pinnules opposite, closely spaced to overlapping (Figs 25B, C), short, broad, rhombic to slightly falcate, apex obtuse; length to width ratio of c. 1.5:1. Venation usually obscure; midvein arising close to the basiscopic margin at c. 45°, then dividing four to five times into venules which radiate

evenly at an acute angle to each other to the pinnule margin; c. 16–22 vein endings around margin.

**Holotype**

AMF113538, part and counterpart, Australian Museum, Sydney.

**Type locality**

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF113522, 113539, 113540, 120972, 120985, all from Coal Mine Quarry.

**Name derivation**

*foleyi* – for Mr Brian Foley, Nymboida Quarries operator, in recognition of his valuable on-site assistance over a period exceeding 30 years.

**Discussion**

*N. foleyi* differs from the other *Nymbopteron* species by the first basiscopic pinnules which are mostly rounded and attached only to the pinna rachis, and by details of the venation pattern in the pinnules.

*Nymbopteron rhomboidale* Holmes gen. et sp. nov.
Figures 27A-D

**Diagnosis**

Medium sized bipinnate frond, pinnae subopposite, closely spaced, first basiscopic pinnules large, square to rounded, attached mostly to the main rachis from which a single vein enters the pinnule, forking four times, ultimate veinlets meeting margin at 90° to main rachis; first acroscopic pinnules forming equilateral triangles between the upper side of the pinna rachis and main rachis, proceeding pinnules rhomboidal, overlapping; midvein short, with several radiating and forking lateral veins.

**Description**

The only specimen (Fig. 27A) is an upper mid portion of a frond with the base and apex missing; estimated length of c. 150 mm; main rachis at broken base 2.5 mm wide, tapering apically to 1.5 mm wide, longitudinally grooved, with six pairs of subopposite broad linear pinnae attached at c. 45° and c. 11 mm apart. First basiscopic pinnules (Fig. 27B) c. 5 mm wide and 5 mm long, attached to basal 3 mm of pinna rachis and 5 mm along the main rachis, distal margin square to rounded, a single vein enters the base of the pinnule from the main rachis, forking four times, the ultimate venules are parallel and pass into the pinnule margin at 90° to the main rachis. First acroscopic pinnules equilateral triangular in shape with proximal margin conjoined to the main rachis; a single vein enters the pinnule from the junction of the pinna rachis with the main rachis, forking three times, with ultimate veinlets parallel to each other and at right angles to the sloping pinnule margin. Succeeding pinnules along the pinnae (Fig. 27D) alternate, overlapping, c. 5 mm wide and 5 mm long hence a length to width ratio of 1:1, rhomboidal, proximal margin curving through 90°, distal margin at right angles to pinna rachis, straight to slightly convex, apex acute, a single vein enters the pinnule at a very acute angle, forking four to six times, with adaxial branches running parallel to the pinna rachis and the other veins radiating evenly to the pinnule margin where there are 16–22 vein endings, distal pinnules decreasing in size and becoming rounded.

**Holotype**

AMF113556, Australian Museum, Sydney.

**Type locality**

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Name derivation**

*rhomboidale – rhombus*, (Lat.), an equilateral parallelogram with unequal pairs of opposite angles; referring to the shape of the pinnules.

**Discussion**

*N. rhomboidale* differs from all other *Nymbopteron* species by the closely spaced pinnae, by the shorter broader overlapping pinnules and by the distinctive radiating venation. The lateral venation in the proximal portions of the broad overlapping pinnules may be confused as conjoining with the veins of adjacent pinnules as described for *Merianopteris major* Feistmantel (Boureau 1975).

*Nymbopteron uncinatum* Holmes gen. et sp. nov.
Figure 28A

**Diagnosis**

A large bipinnate frond with broad uncinate basal basiscopic pinnules.

**Description**

*N. uncinatum* is based on two incomplete specimens of large bipinnate fronds, both over 200 mm long and with bases and apices missing. On the portion preserved of the holotype (Fig. 28A) the main rachis is smooth, 4 mm wide at the broken base, tapering gradually upwards, with 15 pairs of opposite, straight pinnae to 80 mm long attached at c. 45°. The

specimen AMF120969 has 10 pairs of opposite pinnae to 60 mm long attached at c. 60° to 80°. First basiscopic pinnules attached in the angle between the main and pinna rachises, triangular to 10 mm long, with recurving tip which forms a broad hook-like outline; first acroscopic pinnule vertically elongate and conjoined to the main rachis. Succeeding pinnules opposite to subopposite, separated to the base except at the distal extremity of the pinnae where they coalesce, broadly triangular to slightly falcate with proximal margin broadly convex, the distal margin straight or slightly convex, c. 8 mm long and c. 4 mm wide with a length to width ratio of 2:1. Venation not preserved.

**Holotype**

AMF120968, Australian Museum, Sydney.

**Type locality**

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF120969, Coal Mine Quarry.

**Name derivation**

*uncinatum* – (Lat.), *hooked*, referring to the hook-shaped outline of the first basiscopic pinnules.

**Discussion**

*N. uncinatum* differs from all other *Nymbopteron* species by its larger and more robust frond size and by the hook-shaped outline of the first basiscopic pinnules. The main and pinna rachises of *N. uncinatum* appear to be rounded and smooth in contrast to the ribbed and grooved rachises of *N. dejerseyi* and *N. foleyi.* This feature may be real or perhaps it is an artifact dependent upon the orientation or deterioration of the frond in the sediment at the time of fossilisation (see comments on *Osmundopsis scalaris* in Holmes 2001b).

*Nymborhipteris* Holmes gen. nov.

*Nymborhipteris radiata* Holmes gen. et sp. nov.
Figures 29A, B

**Combined diagnosis**

Medium sized bipinnate frond, stout main rachis, pinnae alternate, bearing opposite sub-circular pinnules with radiating and forking venation.

**Description**

A fragment of a mid-portion of a bipinnate frond; main rachis on portion preserved longitudinally wrinkled, 7 mm wide, tapering to 6 mm over length of 90 mm; total length of frond estimated to reach 300 mm. Pinnae sub-opposite to alternate, 11–15 mm apart, attached at c. 60°, straight, length unknown. Pinnules opposite, sub-circular, base broadly attached but slightly constricted basiscopically, margin entire, apex rounded; a single decurrent vein enters the base, soon dividing four times into finer veins which again fork two or three times to radiate throughout the lamina with c. 24 vein endings around the margin.

**Holotype**

AMF113489, Australian Museum, Sydney.

**Type locality**

Reserve Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Name derivation**

*nymborhipteris* – contrived; from *Nymboida,* the source of the material; *rhipis,* (Gr.) *fan*; *pteris*, (Gr.) *fern*; referring to the fan-shaped appearance of the pinnules.

*radiata* (Lat.), *radiating*, referring to the venation pattern in the pinnules.

**Discussion**

*N. radiata*, the type species of the monotypic genus *Nymborhipteris,* is based on a single fragmentary specimen (Fig. 29A). The stout striated main rachis and the venation pattern distinguishes *N. radiata* from the forked bipinnate fronds of the corystosperm *Dicroidium zuberii* (Retallack 1977; Anderson and Anderson 1983). In gross morphology this frond differs from all known Gondwana material.

*Ptilotonymba* Holmes gen. nov.

*Ptilotonymba curvinervia* Holmes gen. et sp. nov.
Figures 30A-C, 31

1977 *Arctopteris* sp? Retallack in Retallack et al. p. 86, Fig. 5C

1977 *Cladophlebis* sp. cf *C. oblonga*, Bourke et al. Fig. 3.2

**Combined diagnosis**

Medium to large bipinnate frond; pinnae broad-linear; pinnules strongly decurrent, rhombic; venation asymmetrical; two lateral veins attached to pinna rachis; 4–6 basiscopic lateral veins once forked or simple, slightly recurved; 3–4 acroscopic lateral veins mainly unforked, arching to follow parallel to pinnule margin.

**Description**

This morpho-taxon is based on five fragments of bipinnate fronds. The holotype (Figs 30B, C) shows incomplete pinnae to 80 mm long in two parallel lots of four apparently attached to separate main rachises. Fig. 31 is a portion of a large frond with the main rachis 18 mm wide near base, decreasing to 12 mm over the 300 mm length preserved, which suggests a total length in excess of 1 metre. Pinnae opposite, to >80 mm long, 20–30 mm apart. Pinnules rhomboidal to rectangular, alternate overlapping, c. 7–10 mm long and 5–6 mm wide, base broad, decurrent on basiscopic side, contracted on acroscopic side, length to width ratio of proximal pinnules c. 1.6:1, margin entire, apex acute to obtuse. Pinnule midvein entering pinnule at c. 30°, arching to c. 45°, at 2/3 of way through lamina to fork and continue as two parallel veins to the apex. Four pairs of asymmetrical lateral veins attached at c. 45°. First one or two lateral veins on basiscopic side of the pinnule fork twice, subsequent veins forking once or unforked near apex, running straight or slightly recurved and parallel to each other to the pinnule margin. On the acroscopic side of the midvein four lateral veins are attached at c. 30°, once forked, the proximal one or two recurving strongly to follow parallel to the pinnule margin for half its length; subsequent veins leaving the midvein at c. 30° and running parallel to each other round distal portion of pinnule margin. Two veins enter the decurrent portion of each pinnule at 45° directly from the main rachis, first vein simple, second vein once forked; 14-18 or more vein endings around pinnule margin with twice as many endings on the basiscopic margin as on the acroscopic margin. Distally the pinnules coalesce and the pinna becomes lobed to entire.

**Holotype**

AMF113479, Australian Museum, Sydney.

**Type locality**

Coal Mine Quarry, Nymboida. Basin Creek Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF11380-83, Coal Mine Quarry.

**Name derivation**

*Ptilotonymba – ptilotos*, (Gr.) *feathered*, referring to the feather-like appearance of the pinnules; *nymba,* for Nymboida, the source of the material.

*curvinervia* – contrived, for the strongly arching lateral veins.

**Discussion**

*Ptilotonymba* is a monotypic genus with *P. curvinervia* as the type species. *Arctopteris* sp? of Retallack (in Retallack et al. 1977) and *Cladophlebis* sp. cf *C. oblonga* (Bourke et al. 1977) are frond fragments that agree with *P. curvinervia. Arctopteris* spp from the Lower Cretaceous of Siberia (Samalyna 1964; Boureau 1975) have similar curving lateral venation and coalescing pinnules, but differ by the unforked lateral veins and by the presence of pinnules decurrent on, or attached directly to, the main rachis between the pinnae. *Pecopteris arcuata* Halle (1927 pl. 19, Figs 1-7; pl.20, Figs 1-13) from the Palaeozoic of China has closely spaced to coalescing pinnules with curving venation similar to *P. curvinervia,* but differs by the opposite arrangement of the pinnules and by the unforked lateral veins.

Genus *Sphenopteris* (Brongniart) Sternberg, 1825
Type species *Sphenopteris elegans* (Brongn.) Sternberg 1825, see Boureau 1975 pp 427-429

*Sphenopteris speciosa* Holmes sp. nov.
Figures 32A-D

**Diagnosis**

Medium sized bipinnate frond. Pinnae opposite. Pinnules elongate triangular with deeply incised lobes on proximal pinnae, decreasing in size, number of lobes and degree of lobation distally and apically. Midvein straight and strong in proximal half of pinnule, decreasing in width and forking in the apical lobe. Lateral veins arching and forking into each lobe.

**Description**

This leaf form is known only from incomplete fronds; the largest being a midportion 150 mm long suggesting a total length of c. 300 mm. Pinnae opposite, recurving, slightly overlapping close to the main rachis; attached at c. 60° to 70°, to c. 100 mm long, 45 mm wide near the base, with up to 10 pairs of pinnules. Pinnules alternate, base contracted, to 25 mm long x 15 mm wide across proximal portion of pinnule, elongate triangular, with to five pairs of deeply incised semicircular lobes, becoming less lobate to entire distally and apically. A single straight midvein traverses each pinnule, decreasing in width and forking in terminal lobe. Lateral veins arch into each lobe, forking to three times into the proximal lobes then decreasingly forked to simple distally.

**Holotype**

AMF113520 and counterpart, Australian Museum, Sydney.

**Type locality**

Coal Mine Quarry, Nymboida. Basin Creek

Formation, Nymboida Coal Measures, Middle Triassic.

**Other material**

AMF113521, UNEF13557, 13558, Coal Mine Quarry.

**Name derivation**

*speciosa* - (Lat.) *showy, beautiful*, for a fossil that I regard as aesthetically pleasing.

**Discussion**

A number of Australian Triassic fronds have been placed in the form genus *Sphenopteris* (Tenison-Woods 1883; Shirley 1898; Walkom 1917, 1928; Jones and de Jersey 1947). However they all differ significantly from *S. speciosa,* which appears to be unique in Gondwana Triassic floras.

Fern bases with radiating fronds
Figures 33A-C, 34A-C

**Description**

Eight specimens in the collection are of rhizomes or stems with closely spaced, spirally attached fronds. Figure 33A shows a number of short, straight and parallel-sided rachises radiating from a common rhizome or stem. One rachis (Fig. 33B) bears four pairs of opposite rounded pinnules 12 mm apart arranged pinnately and apparently attached in a plane at right angles to the main rachis. The size of the three lower pairs of pinnules (pinnae?) is not known as they are compressed at an angle to the bedding plane. The uppermost preserved pinnule is 9 mm long and 7 mm wide. It is ovoid in outline with a contracted base, margin slightly lobed, apex obtuse. The venation is not clear but appears to be an indistinct short median vein that forks repeatedly to form fine lateral veins radiating throughout the lamina. The specimens illustrated in Figs 34A, B have c. 12 frond rachises radiating from a central axis c. 10 mm in diameter. They are all incomplete. From an expanded base, the rachises are smooth, straight, to 4 mm in width and to an incomplete length of 80 mm without pinnae or pinnules. Figure 33C is a vertical section of a rhizome with persistent frond rachises radiating three dimensionally into the matrix.

**Material**

AMF113498-113503, Coal Mine Quarry, Nymboida.

**Discussion**

The growth form and foliage pattern of the specimen with the pinnate rachis can not be related to any other fern or fern-like plant at Nymboida or other Gondwana localities. All these specimens were at first mistaken for isoetalean plants until AMF113498 (Figs 33A, B) demonstrated their fern-like nature. However the poor preservation of the present material does not warrant the erection of a new taxon.

Circinate frond
Figure 33D

Despite the abundance of fern fossils at the Nymboida quarries, the specimen illustrated (AMF113519) is the only example in the collections of a circinate frond. As the specimen is detached and incomplete it cannot be affiliated with any known taxon.

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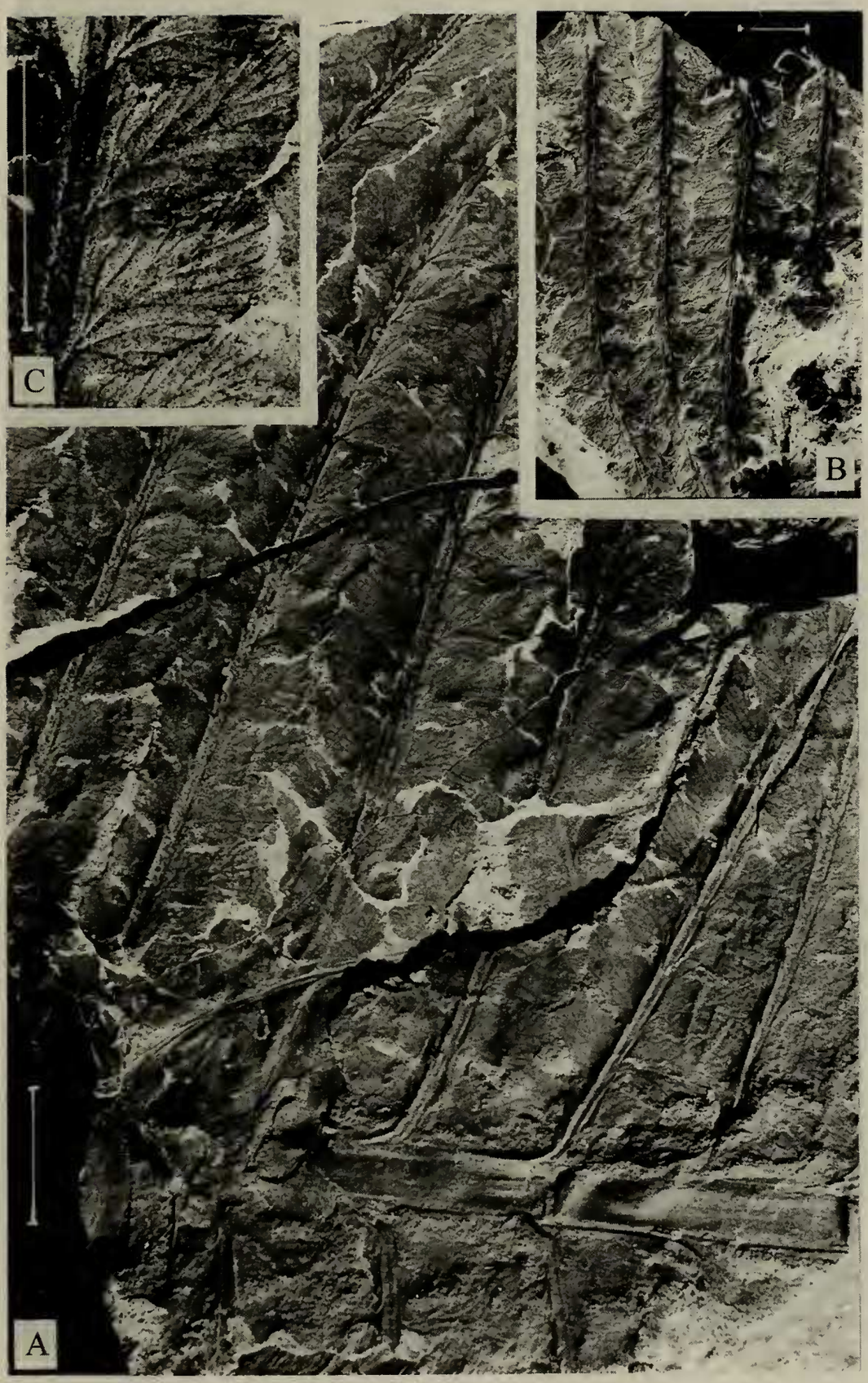


Figure 1. A–C. *Cladophlebis conferta* Holmes sp. nov. A. AMF120987, holotype X2; B. AMF121015; C. AMF120987, X4. Scale bar = 1 cm.

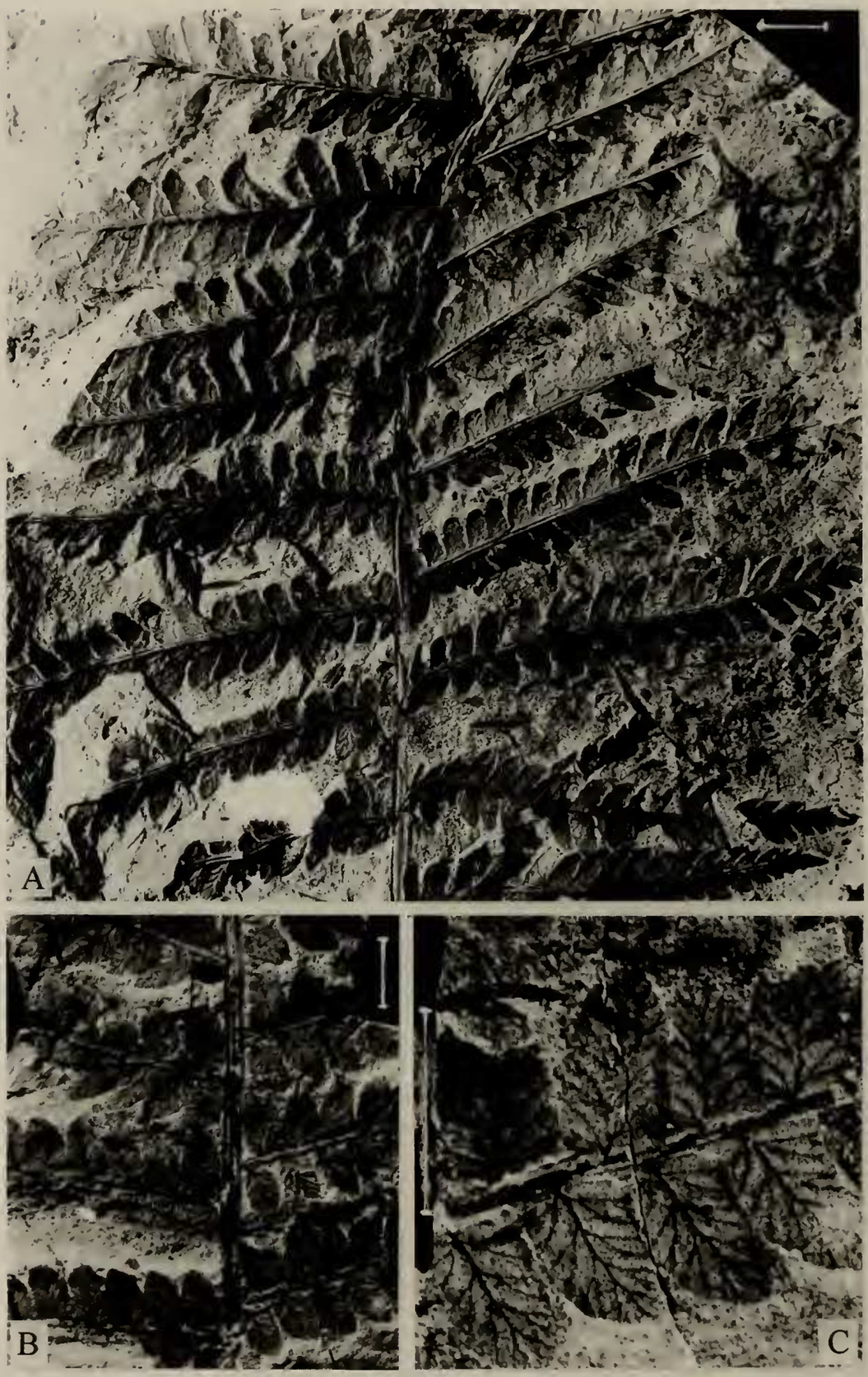


Figure 2. A–C. *Cladophlebis octonerva* Holmes sp. nov. A. AMF113484, holotype; B. AMF113485; C. AMF113485, X3. Scale bar = 1 cm.

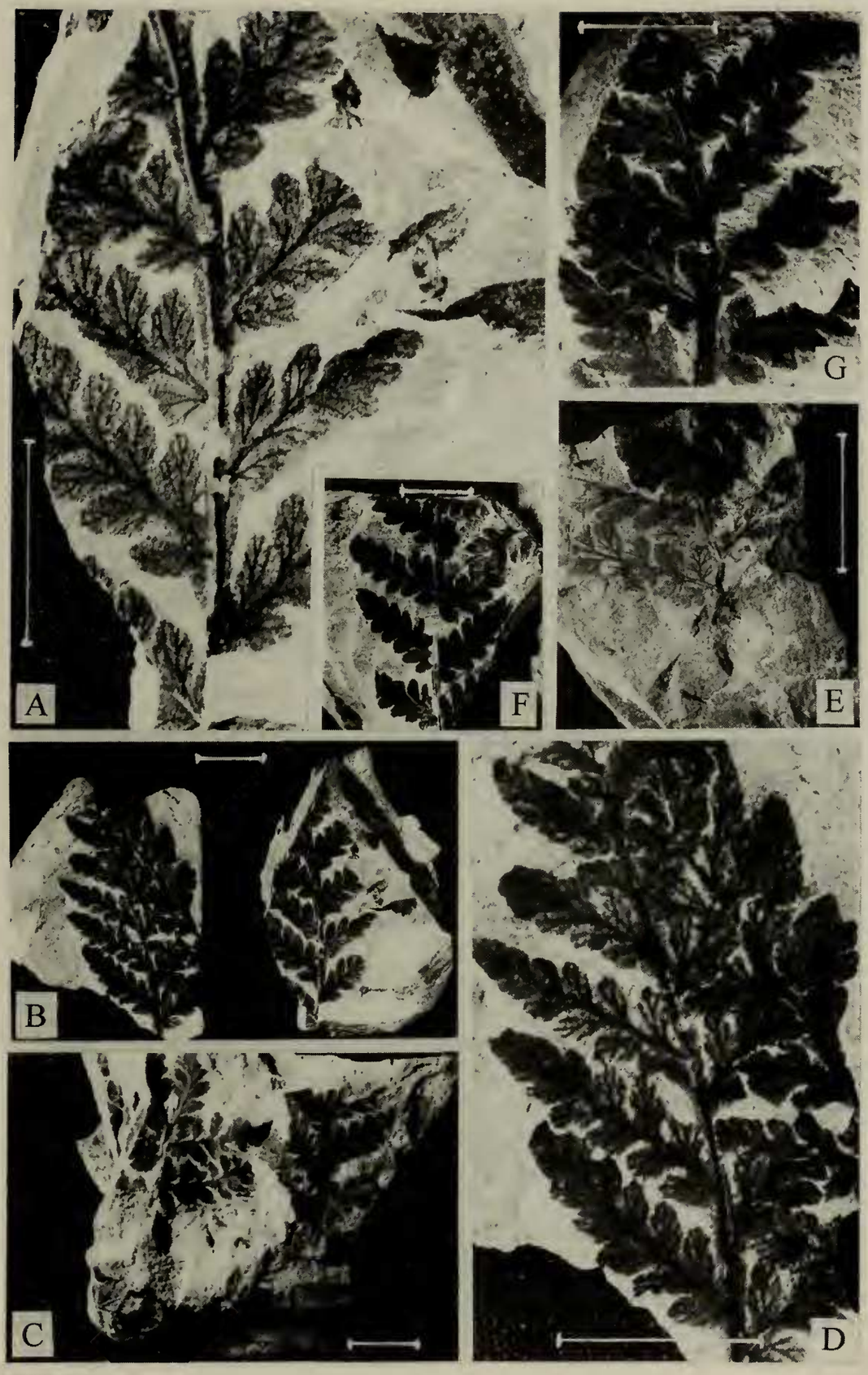


Figure 3. A-G. *Cladophlebis paucinerva* Holmes sp. nov. A. AMF120980, X3; B. AMF120979 and AMF120980 part and counterpart, holotype and isotype; C. AMF120981; D. AMF120979, X3; E. AMF120984, X2; F. AMF120982; G. AMF120983, X2. Scale bar = 1 cm.

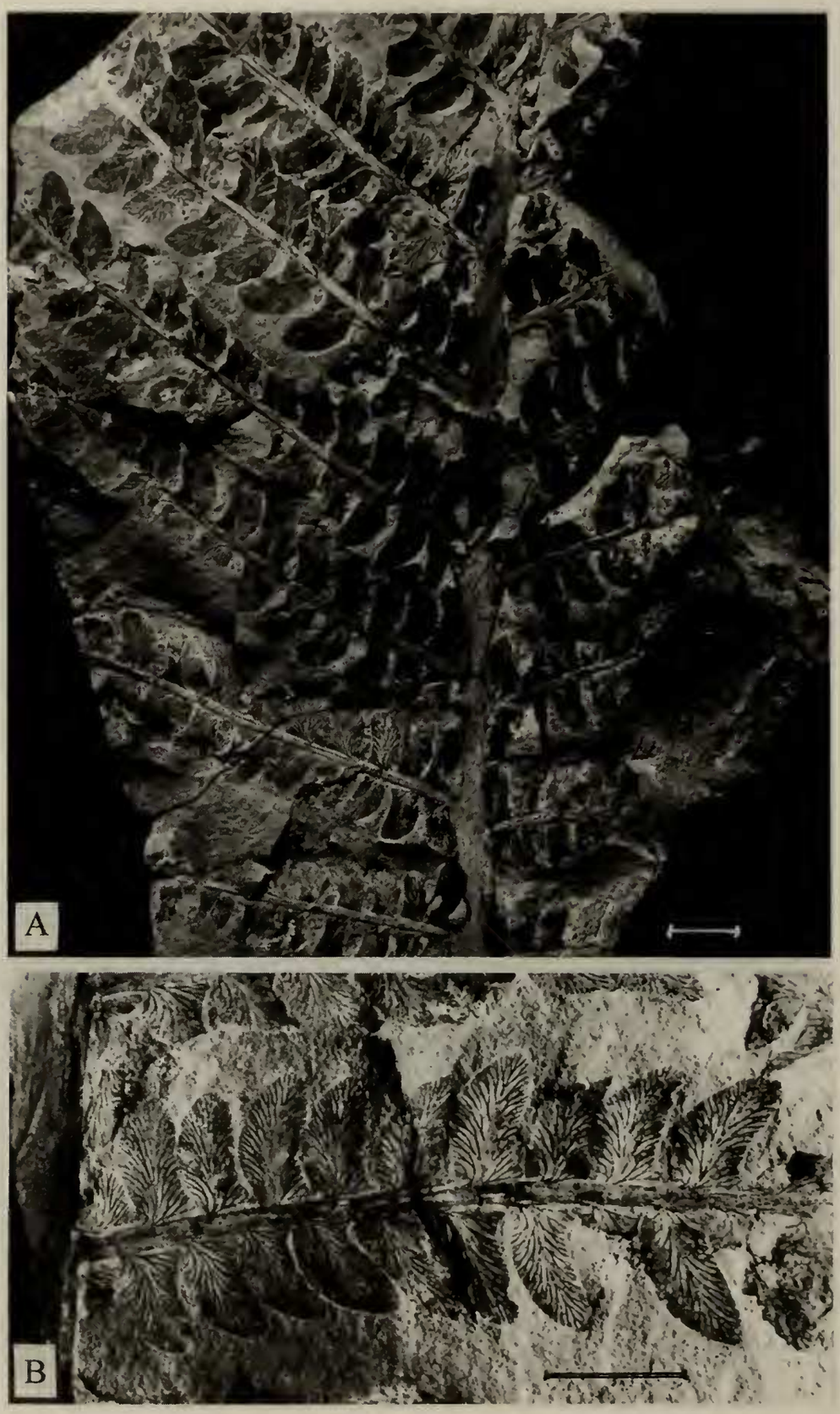


Figure 4. A, B. *Cladophlebis retallackii* Holmes sp. nov. A. AMF120954; B. AMF120958, X2. Scale bar = 1 cm.

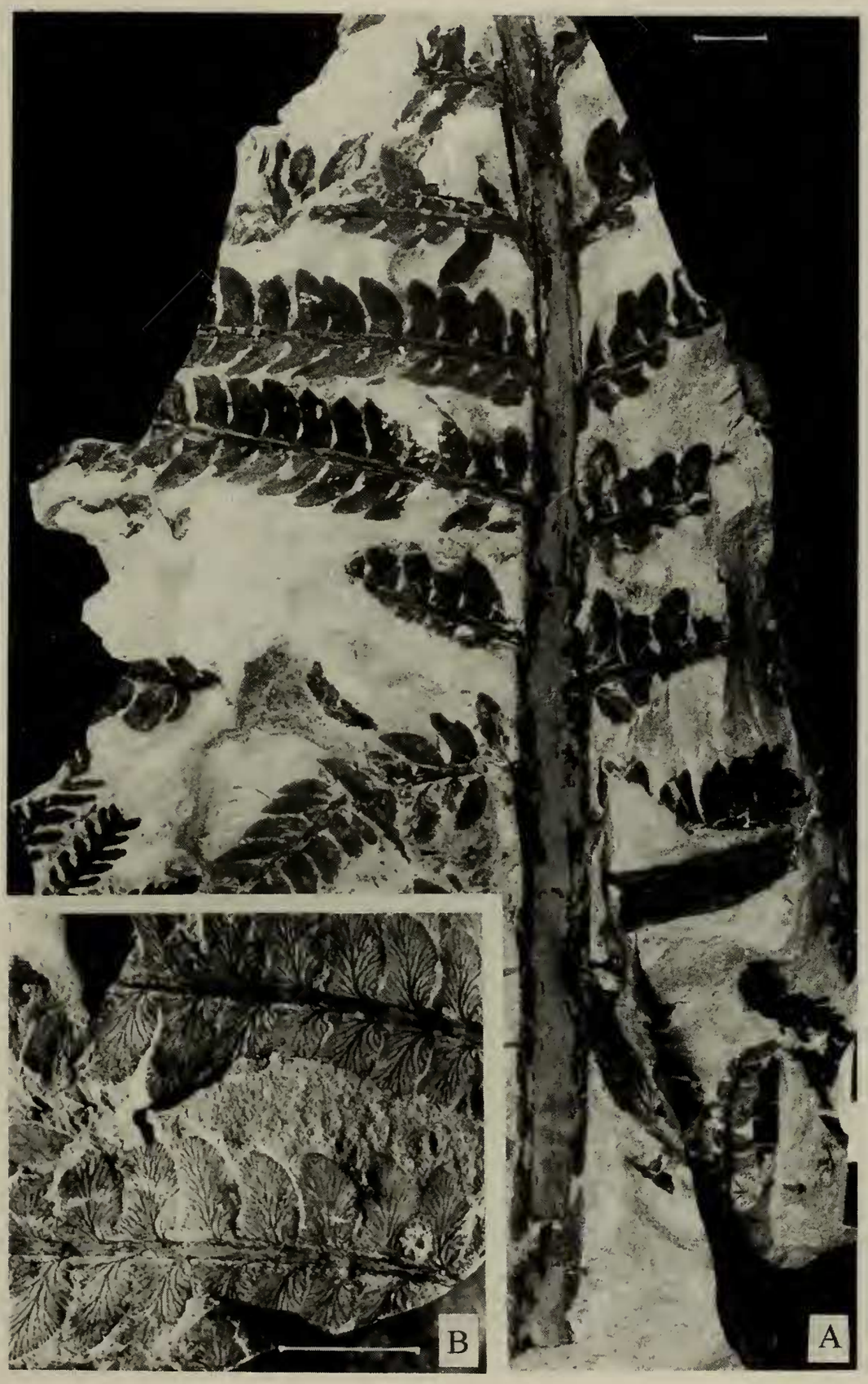


Figure 5. A, B. *Cladophlebis retallackii* Holmes sp. nov. A. AMF120959, holotype; B. AMF120958, X2. Scale bar = 1 cm.

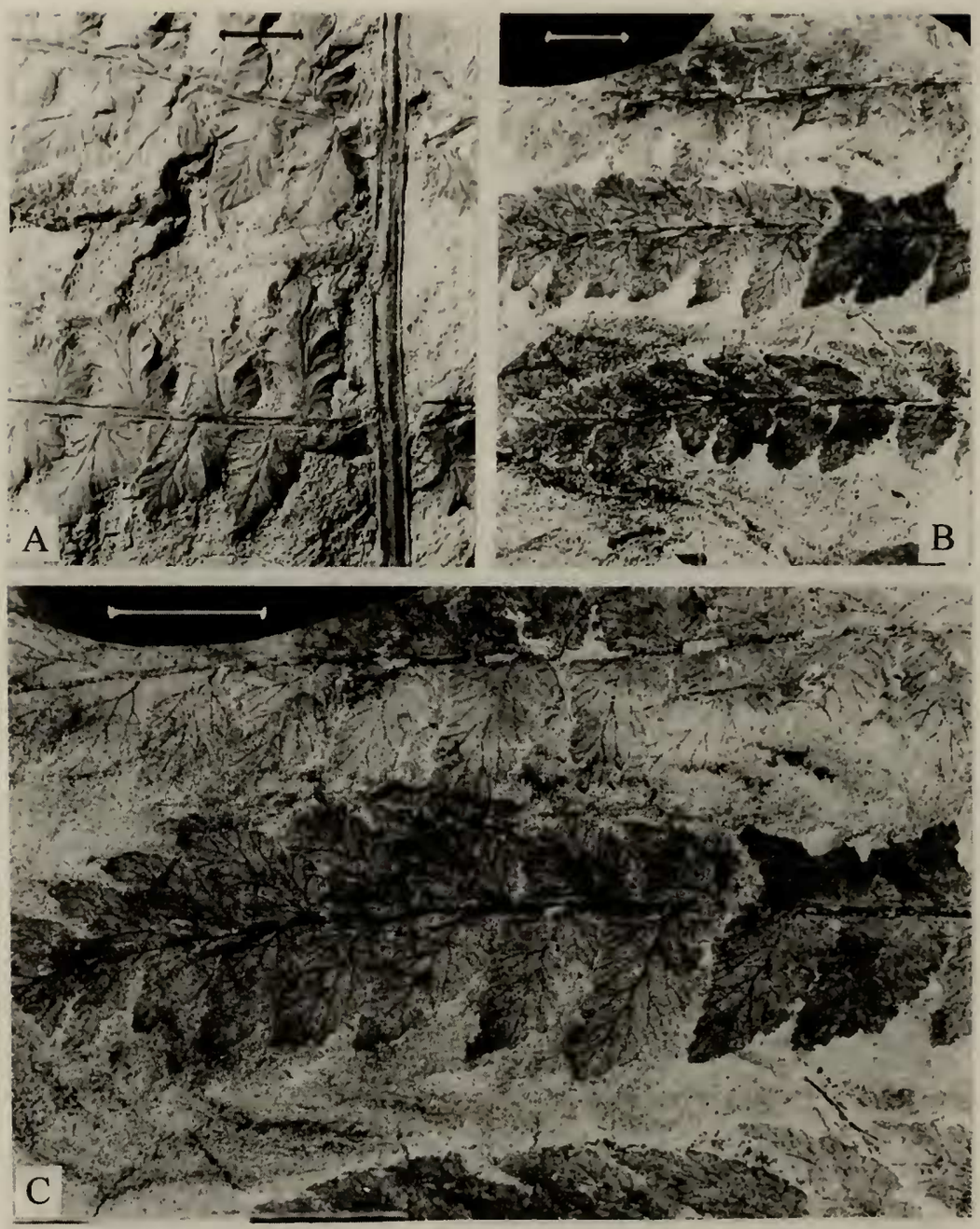


Figure 6. A–C. *Cladophlebis sinuata* Holmes sp. nov. A. AMF113512, holotype; B. AMF113518; C. AMF113518, X2. Scale bar = 1 cm.

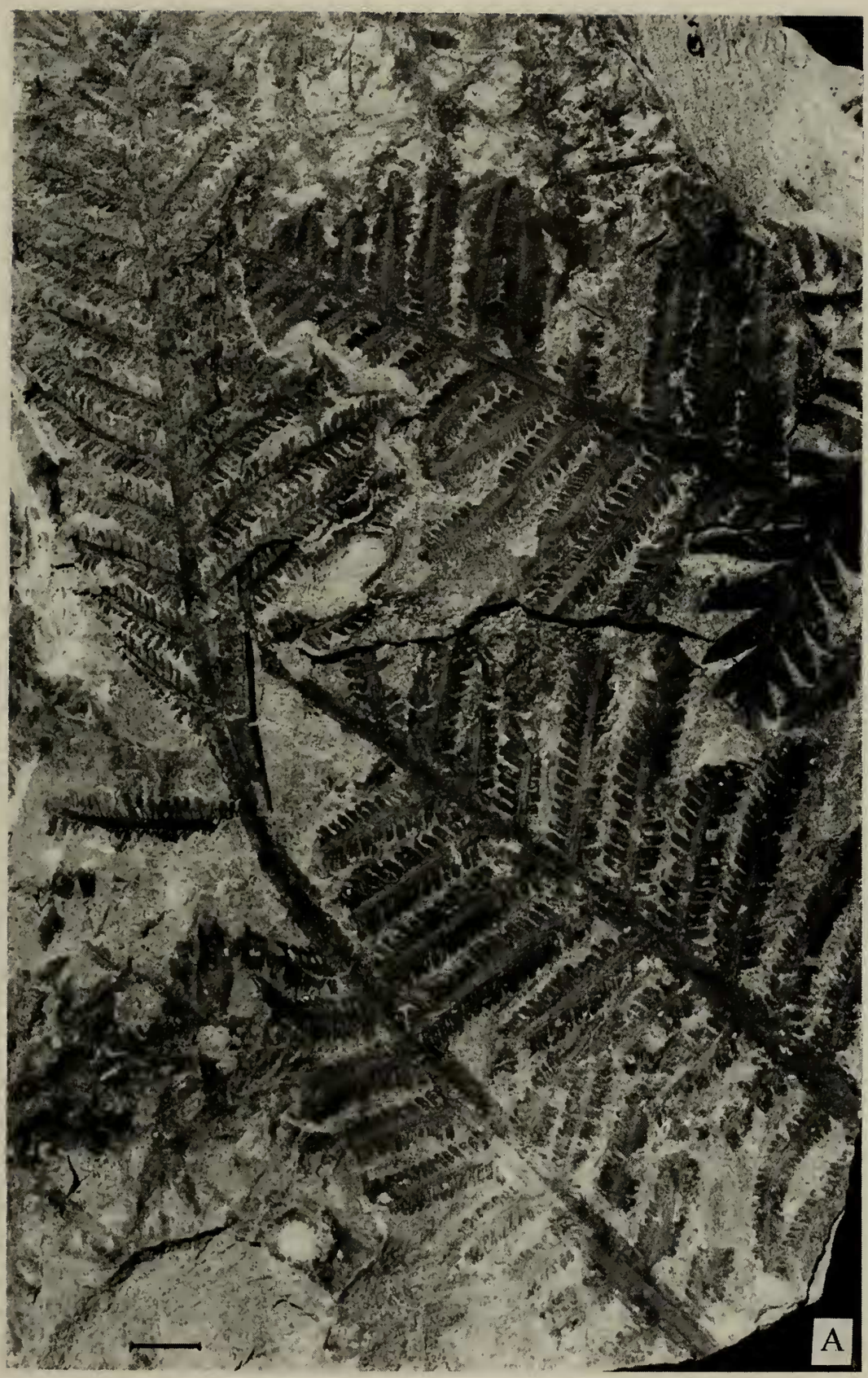


Figure 7. A. *Cladophlebis tenuipinnula* Holmes sp. nov. AMF113523, holotype. Scale bar = 1 cm.

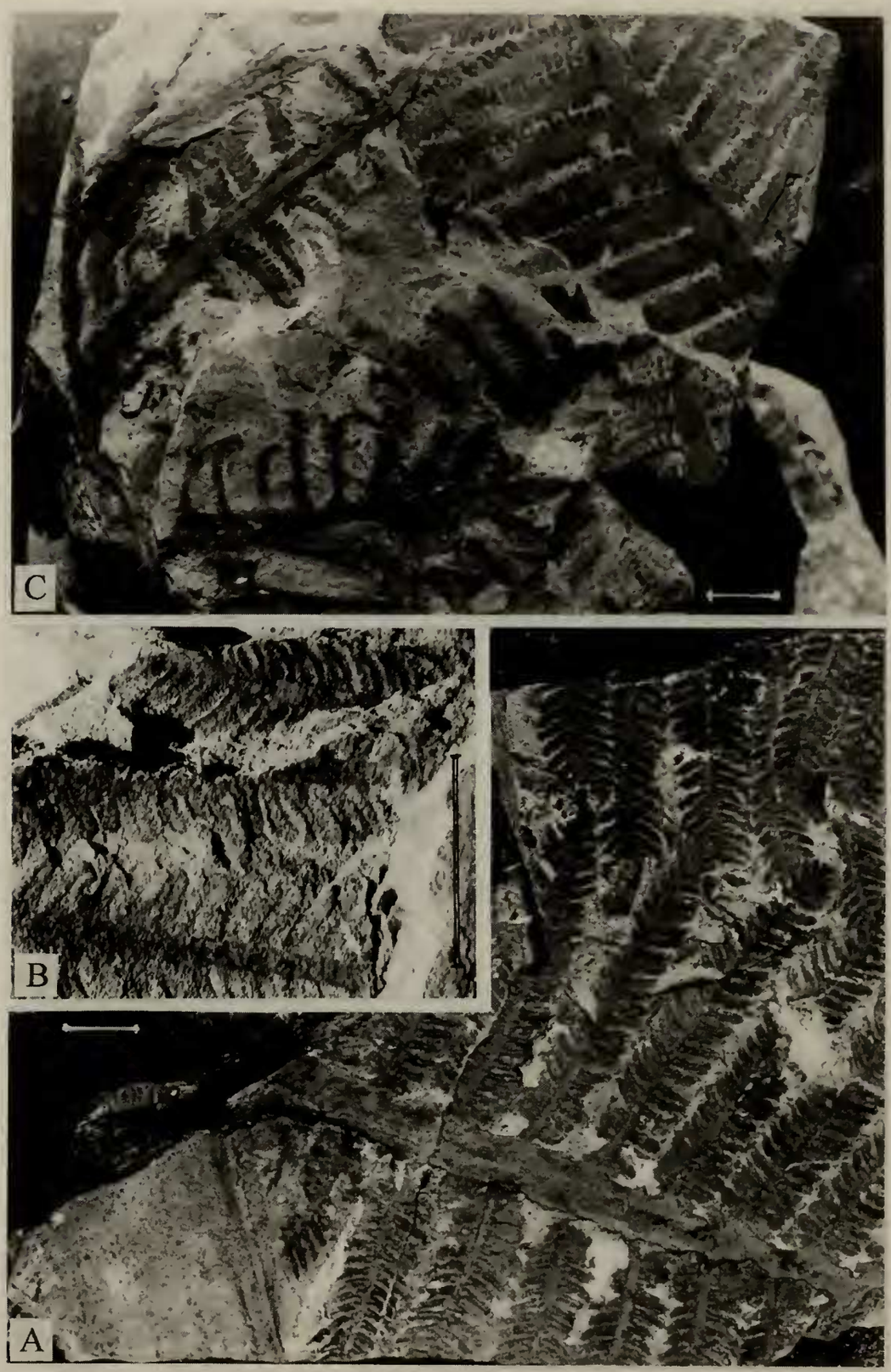


Figure 8. A–C. *Cladophlebis tenuipinnula* Holmes sp. nov. A. AMF113406; B. AMF113526, X3; C. AMF113524. Scale bar = 1 cm.

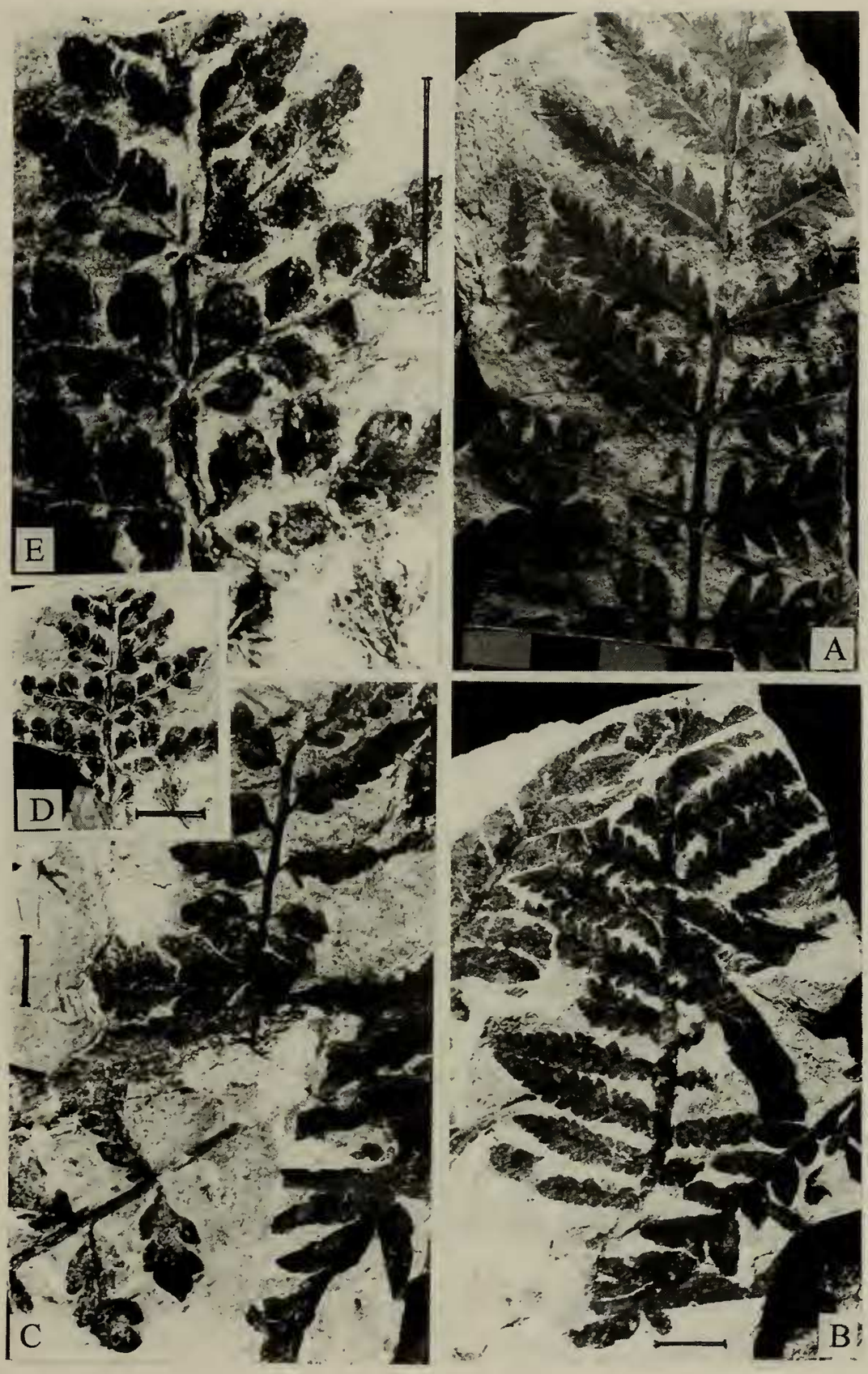


Figure 9. A–C. ?*Cladophlebis* sp.A. A. AMF113508; B. AMF113510; C. AMF113509. D, E. ?*Cladophlebis* sp.B. D. AMF120978; E. AMF120978, X3. Scale bar = 1 cm.

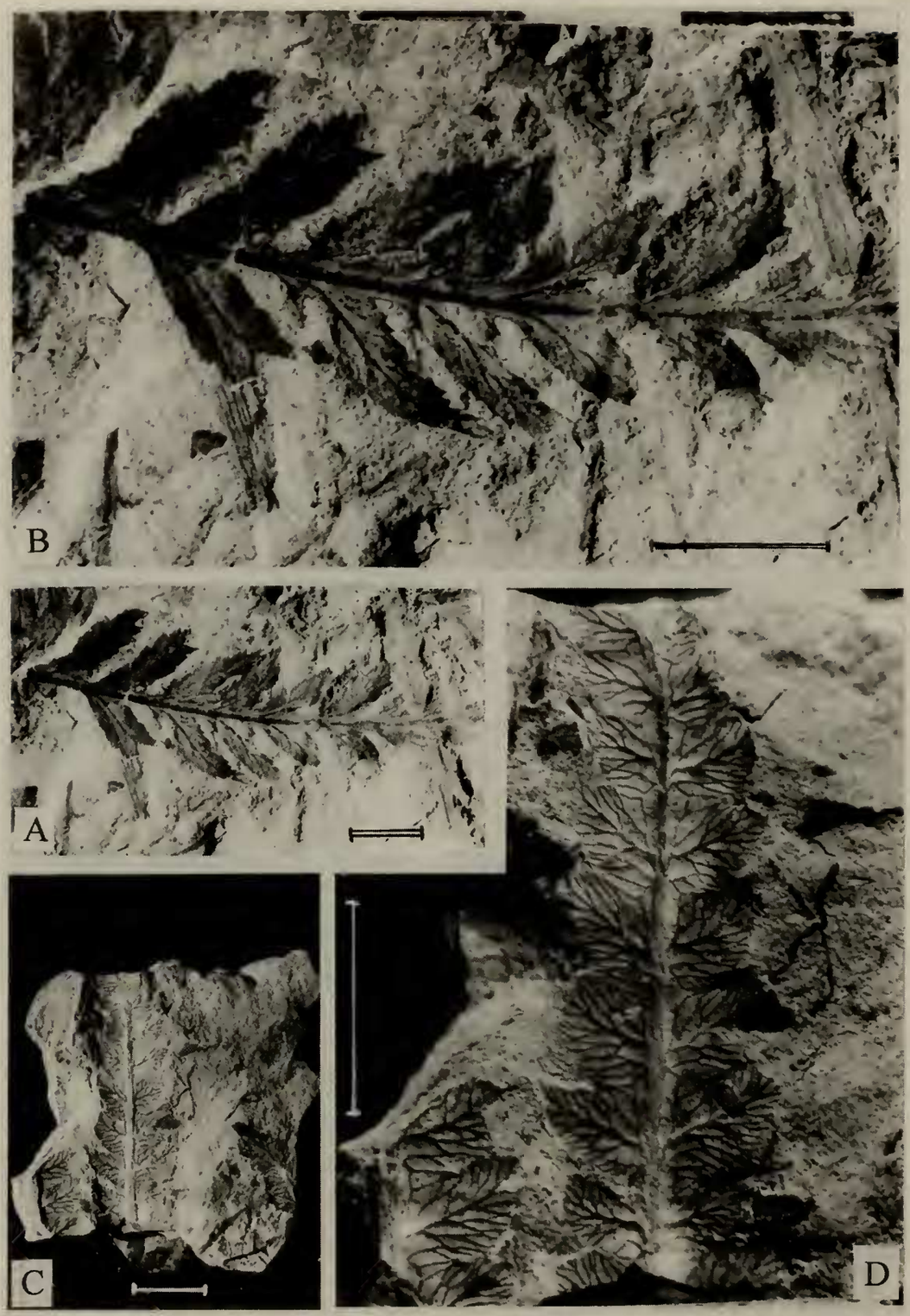


Figure 10. A, B. ?*Cladophlebis* sp.C. A. AMF120994; B. AMF120994, X2.5; C. D. *Dictyonymba sparnosa* Holmes gen. et sp. nov.; C. AMF113507, holotype; D. AMF113507, X3. Scale bar = 1 cm.

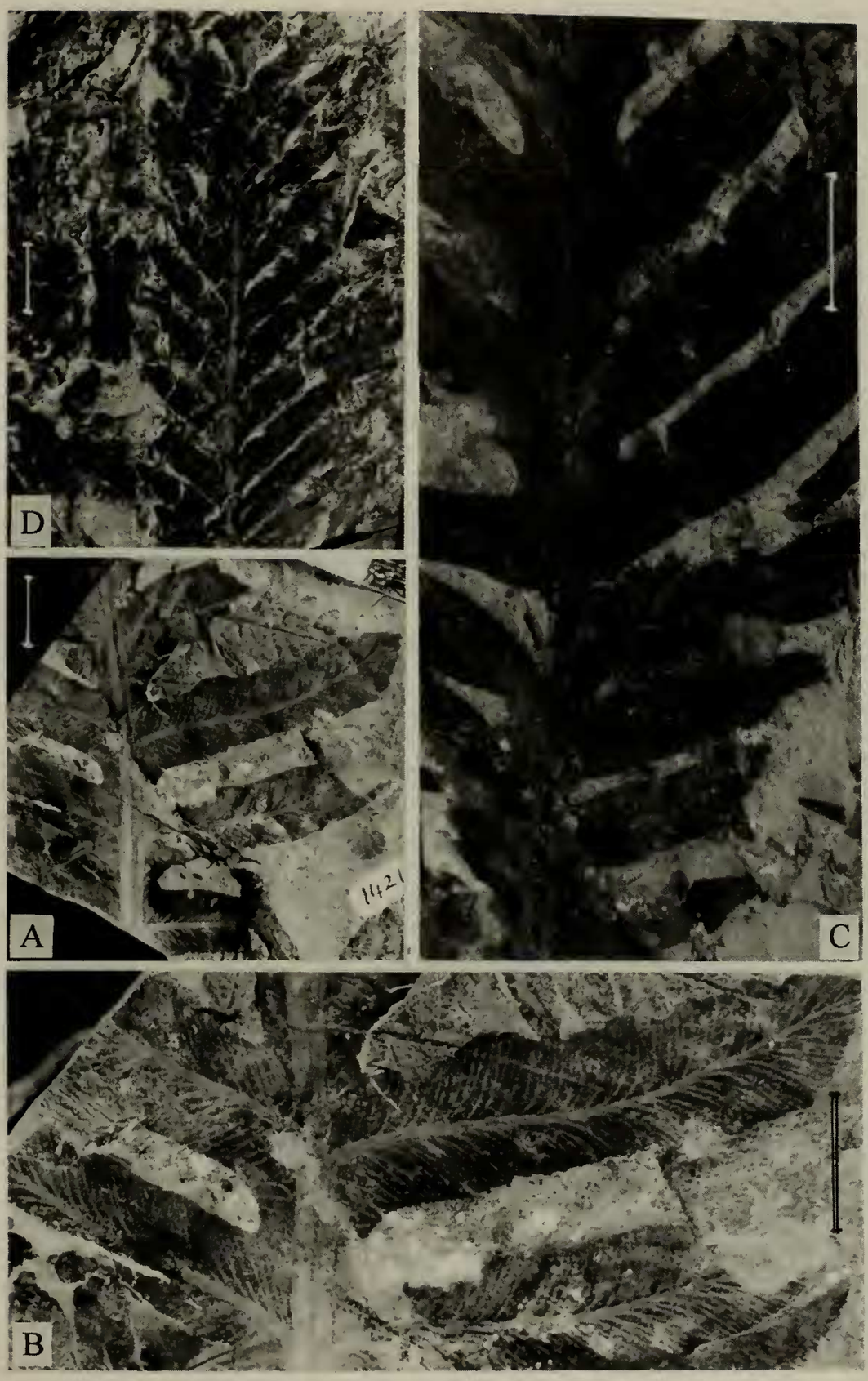


Figure 11. A–D. *Gouldiopteris alethopteroides* Holmes gen. et sp. nov. A. AMF113561, holotype; B. AMF113561, X2; C. AMF113562, X2; D. AMF113563. Scale bar = 1 cm.

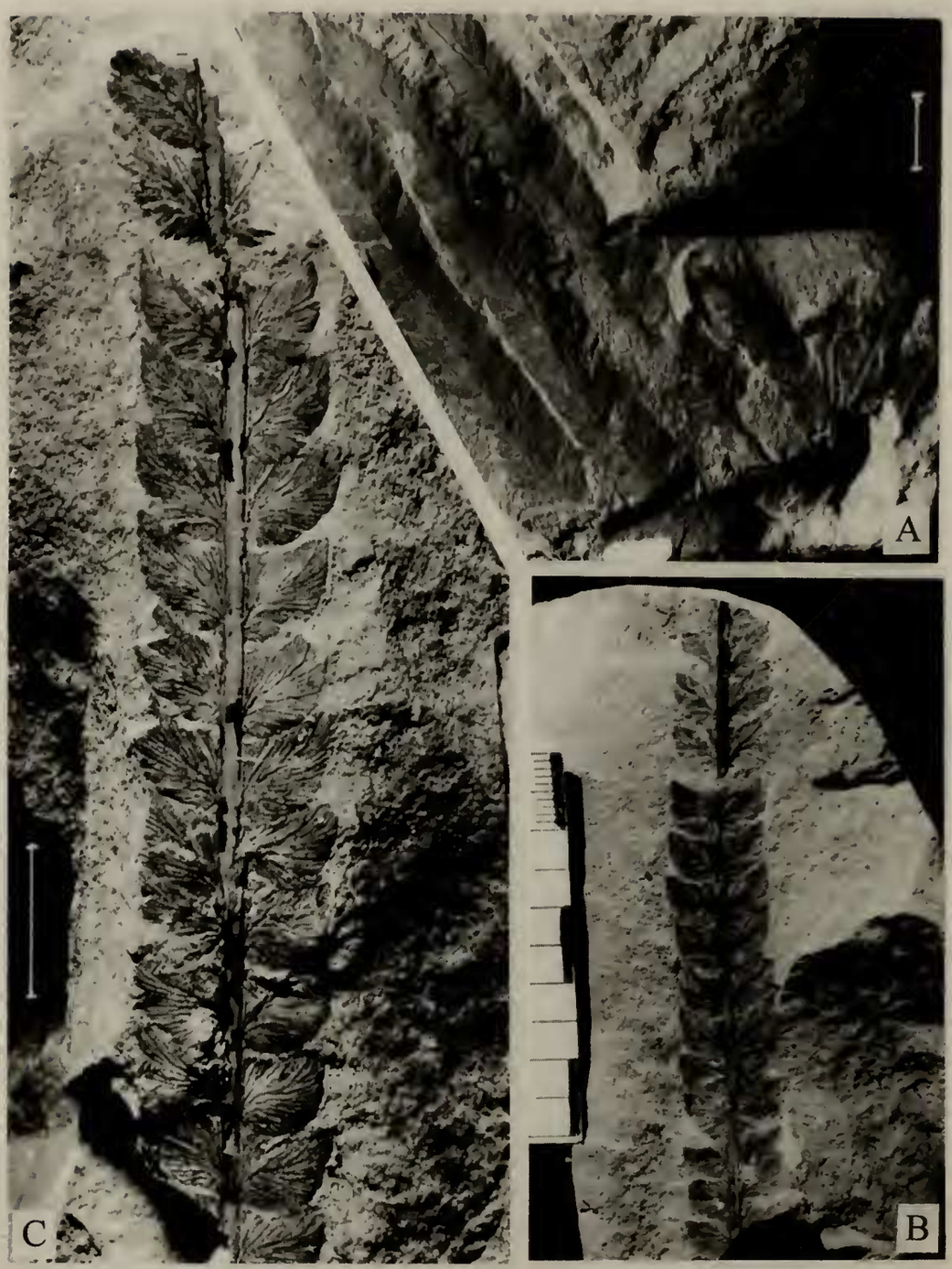


Figure 12. A–C. *Leconama stachyophylla* Holmes gen. et sp. nov. A. AMF121183, holotype; B. AMF121160; C. AMF113544, X2. Scale bar = 1 cm.


Figure 13. A. *Micronymba repens* Holmes gen. et sp. nov. AMF120962, holotype, X2. Scale bar = 1 cm.


Figure 14. A–D *Micronymba repens* Holmes gen. et sp. nov. A. AMF120962, holotype; B. AMF120963, isotype; C. AMF120962, X3; D. AMF120965. Scale bar = 1 cm.


Figure 15. A. *Nymbiella lacerata* Holmes gen. et sp. nov. AMF113530, holotype. Scale bar = 1 cm.


Figure 16. A, B. *Nymbiella lacerata* Holmes gen. et sp. nov. A. AMF113532; B. AMF113533. Scale bar = 1 cm.

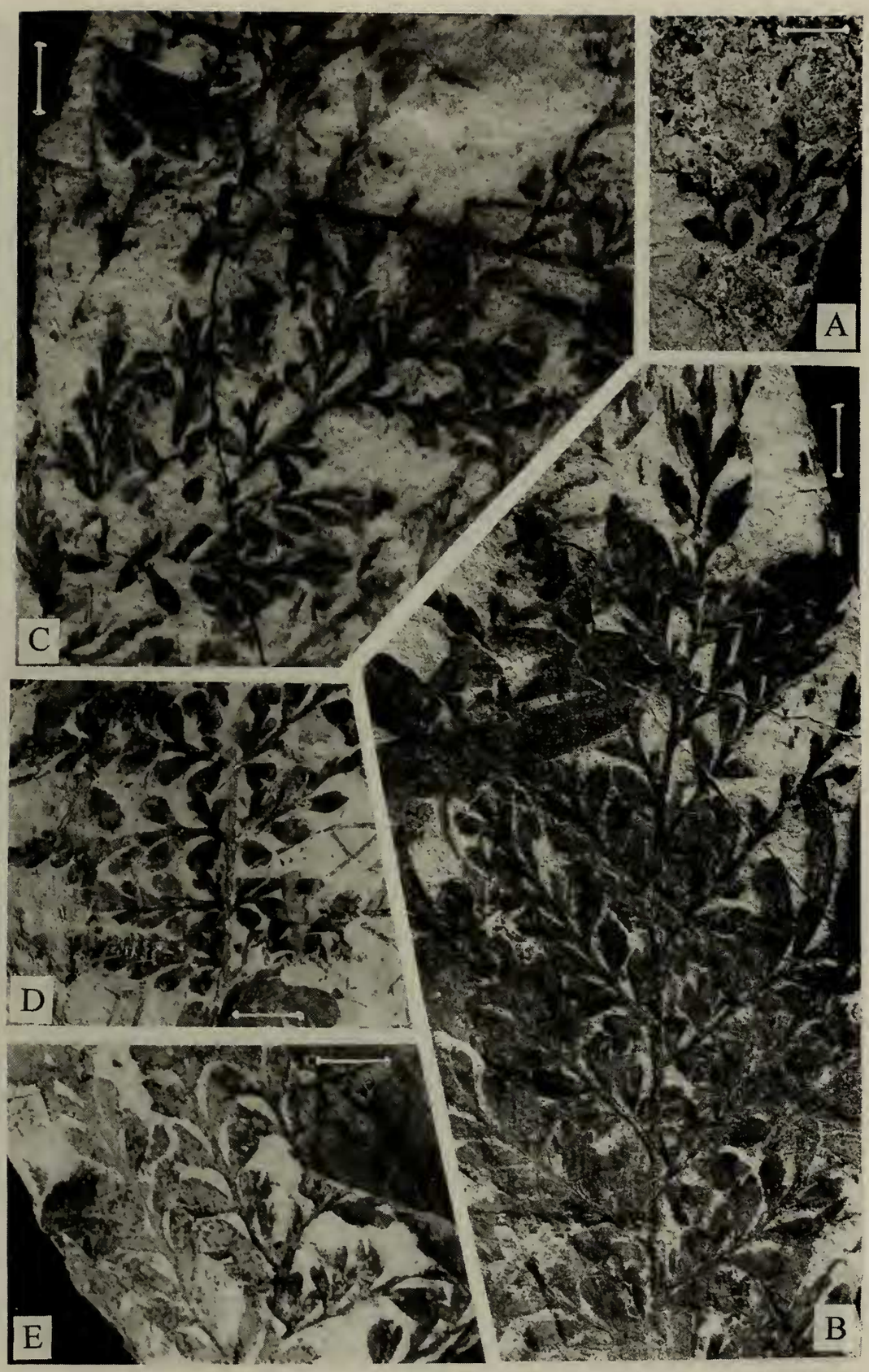


Figure 17. A–E. *Nymboidiantum glossophyllum* (Tenison-Woods) Holmes gen. et comb. nov. A. AMF68449, lectotype; B. AMF120945; C. AMF120946; D. AMF120949; E. AMF120948. Scale bar = 1 cm.


Figure 18. A, B. *Nymboidiantum multilobatum* Holmes gen. et sp. nov. A, B, AMF113558, holotype; B. X2 C, D. *Nymboidiantum glossophyllum* (Tenison-Woods) Holmes gen. et comb. nov.; C. AMF120947; D. AMF12950. Scale bar = 1 cm.


Figure 19. A, B. *Nymboidiantum elegans* Holmes gen. et sp. nov. A. AMF113504, holotype; B. AMF113506 C, D. *Nymboidiantum fractiflexus* Holmes gen. et sp. nov. C. AMF113502, holotype; D. AMF113502, X3. Scale bar = 1 cm.

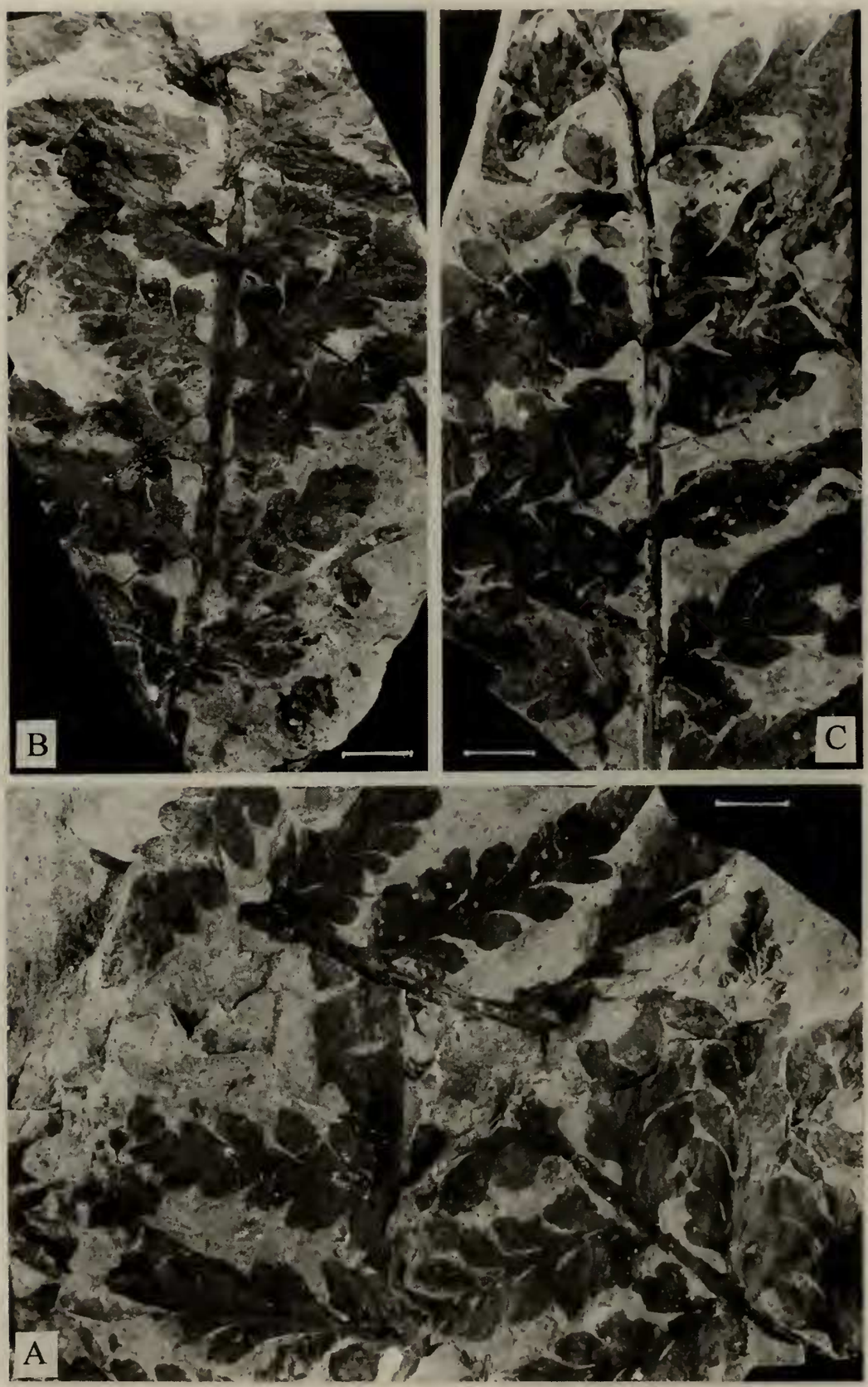


Figure 20. A–C. *Nymboidiantum robustum* Holmes gen. et sp. nov. A. AMF113495; B. AMF113497; C. AMF113496, holotype. Scale bar = 1 cm.

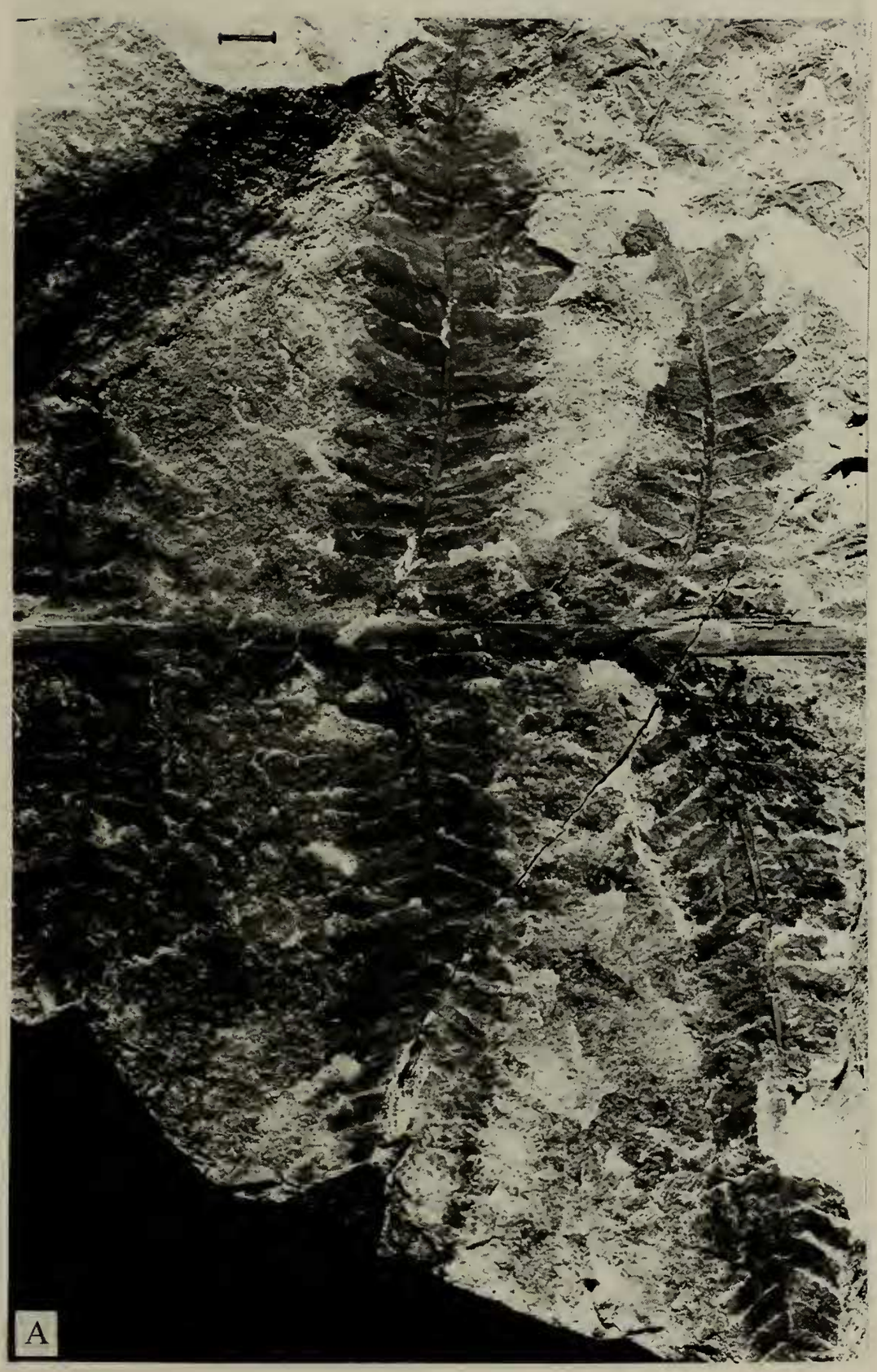


Figure 21. A. *Nymbophlebis polymorpha* Holmes gen. et sp. nov. AMF121010, X0.75. Scale bar = 1 cm.

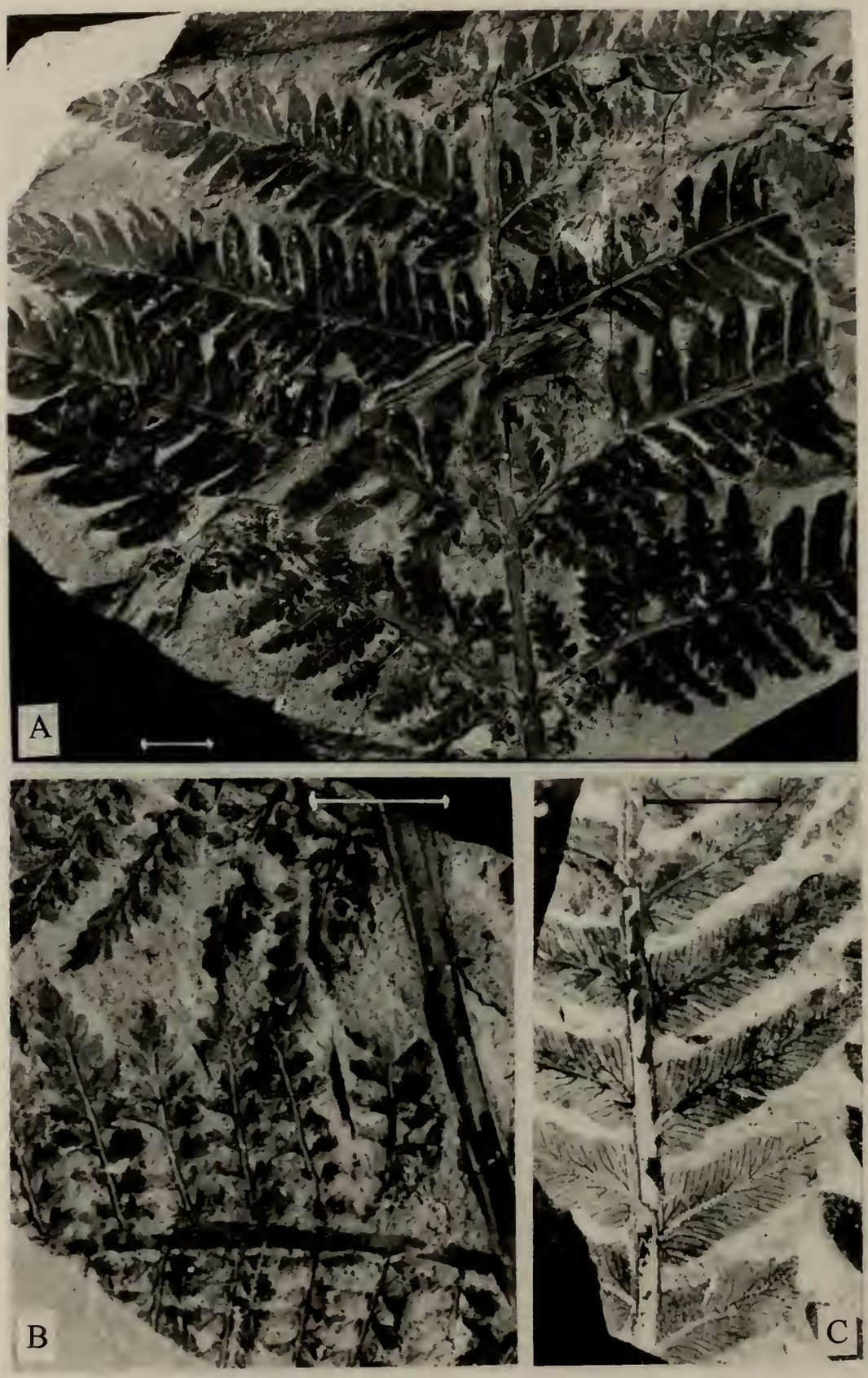


Figure 22. A–C. *Nymbophlebis polymorpha* Holmes gen. et sp. nov. A. AMF120996; B. AMF121000, X2; C. AMF121001, X2. Scale bar = 1 cm.

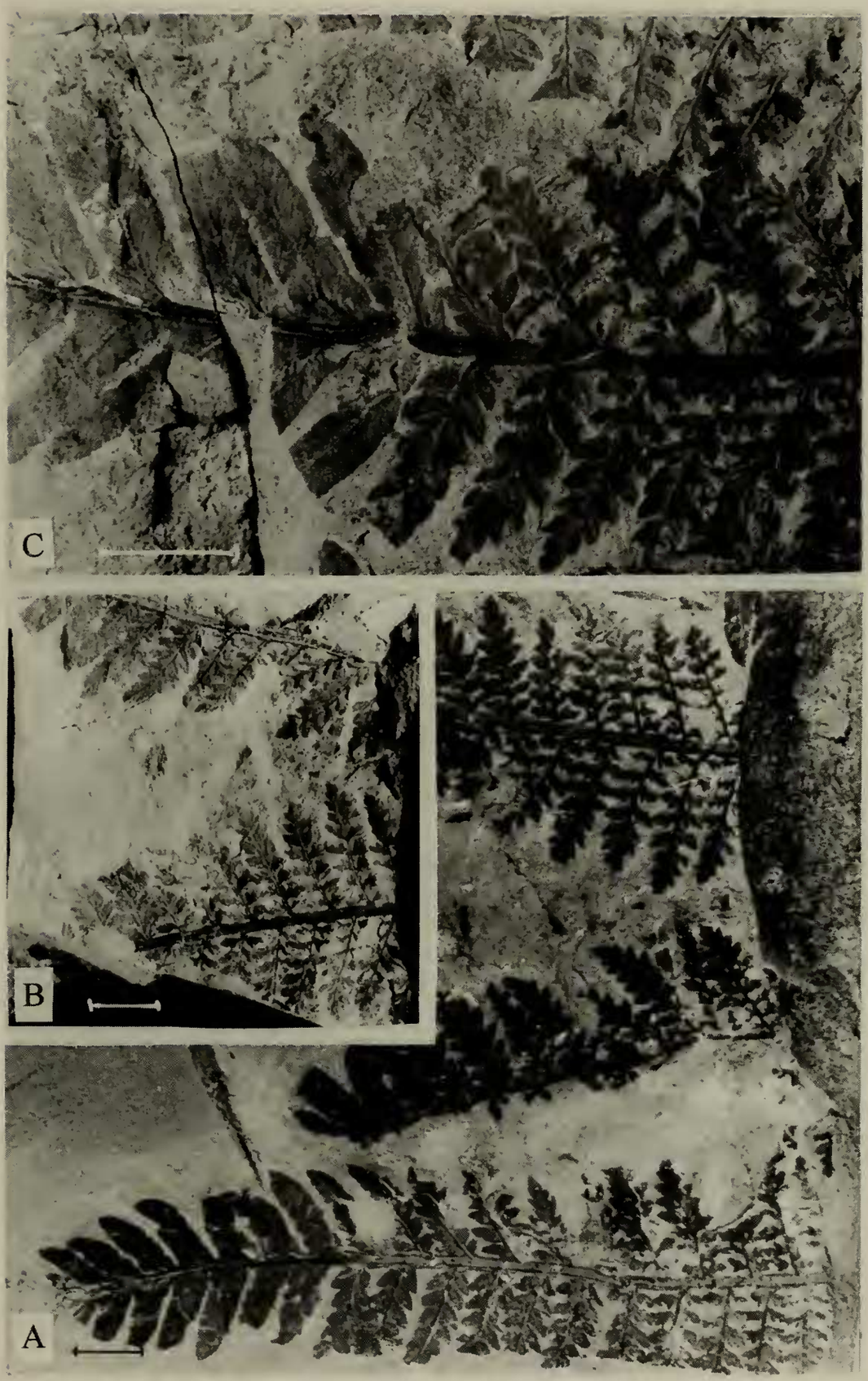


Figure 23. A–C. *Nymbophlebis polymorpha* Holmes gen. et sp. nov. A. AMF120998; B. AMF120999; C. AMF120997, X2. Scale bar = 1 cm.

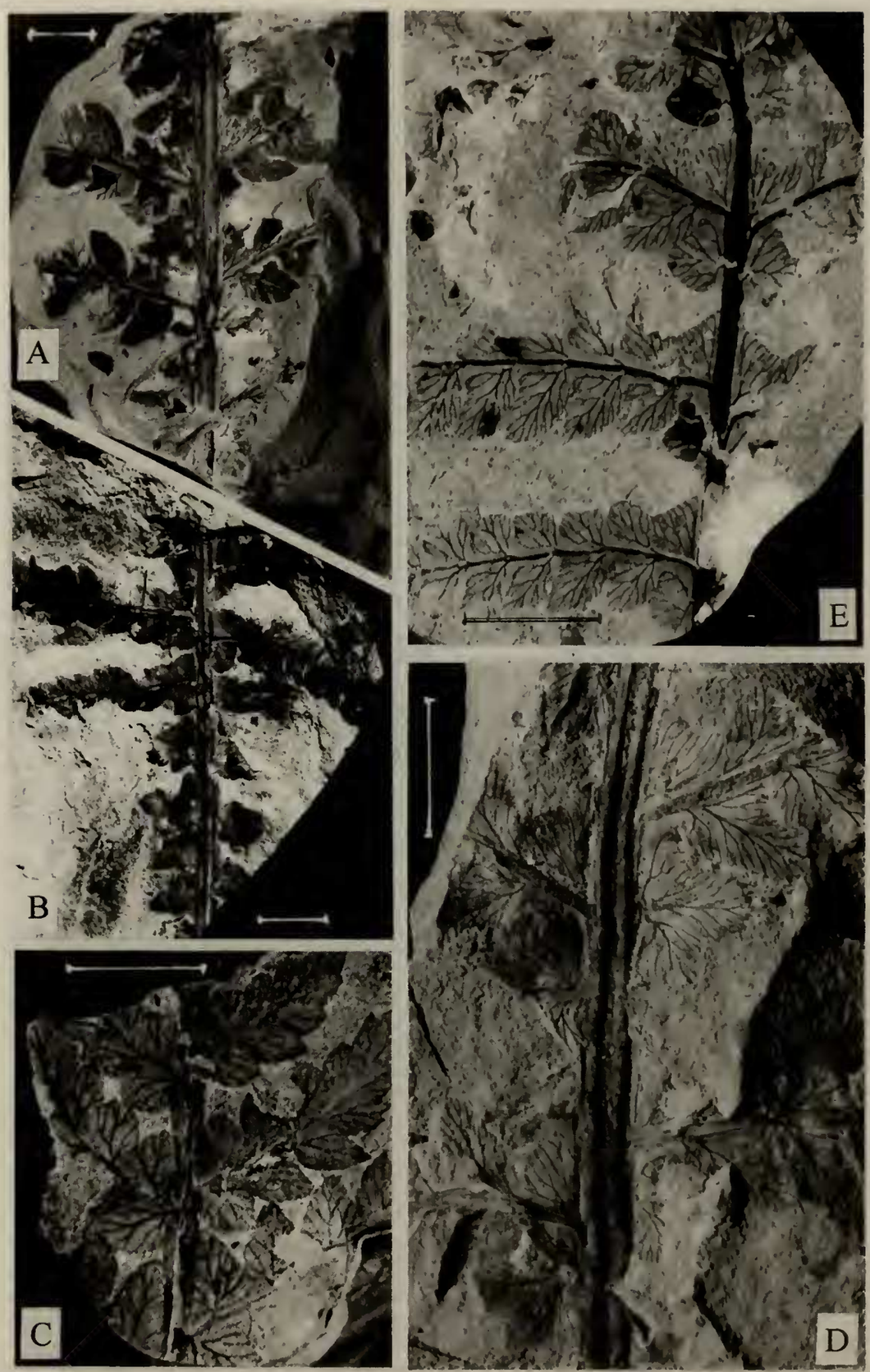


Figure 24. A–E. *Nymbopteron dejerseyi* (Retallack) Holmes gen. et comb. nov. A. AMF113549; B. AMF113548; C. AMF113549, X2; D. AMF113545, X2; E. AMF113547, X2. Scale bar = 1 cm.

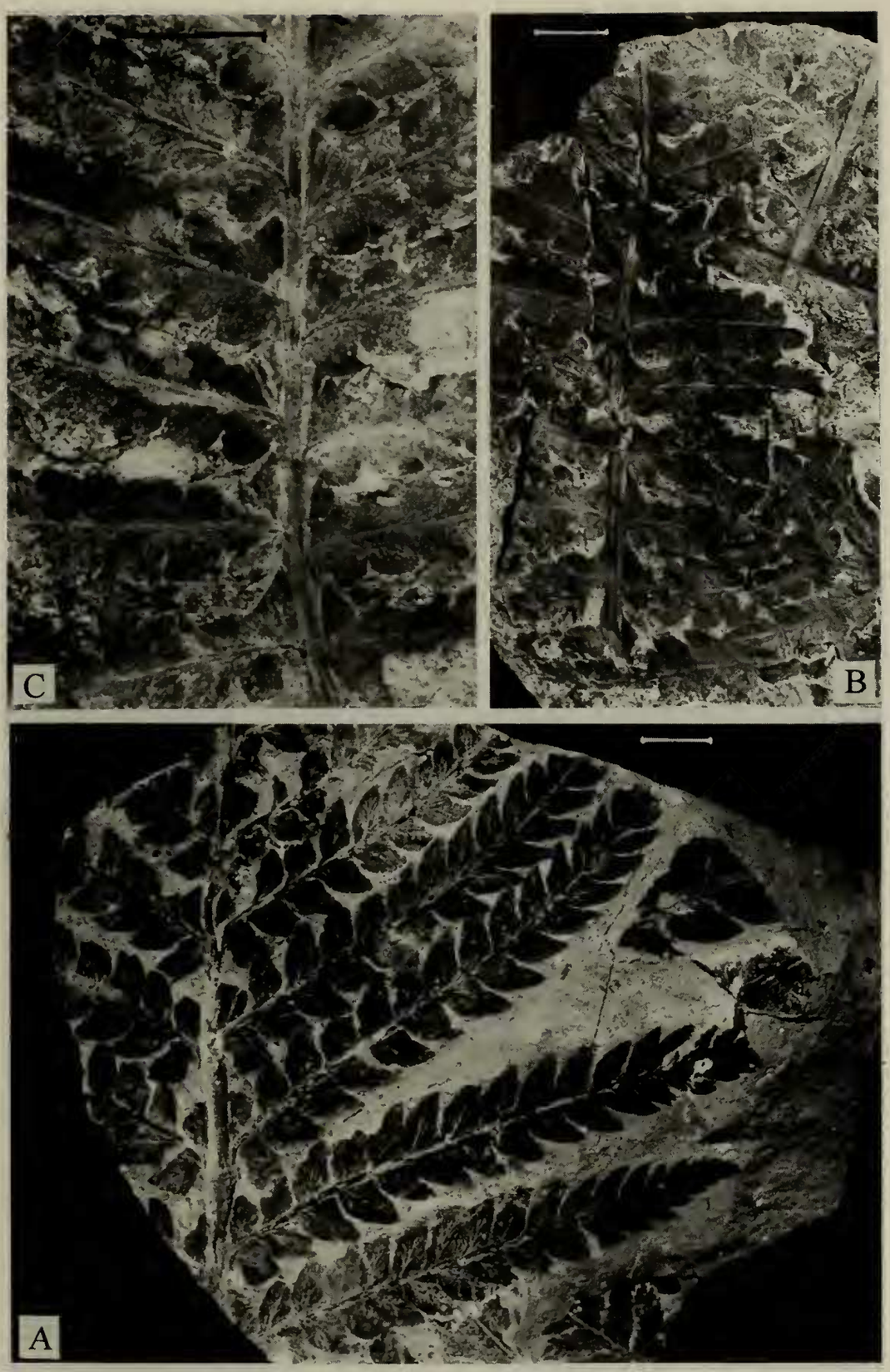


Figure 25. A. *Nymbopteron dejerseyi* (Retallack) Holmes gen. et comb. nov. AMF121158, holotype. B, C. *Nymbopteron foleyi* Holmes gen. et sp. nov. B. AMF113540; C. AMF113522, X2. Scale bar = 1 cm

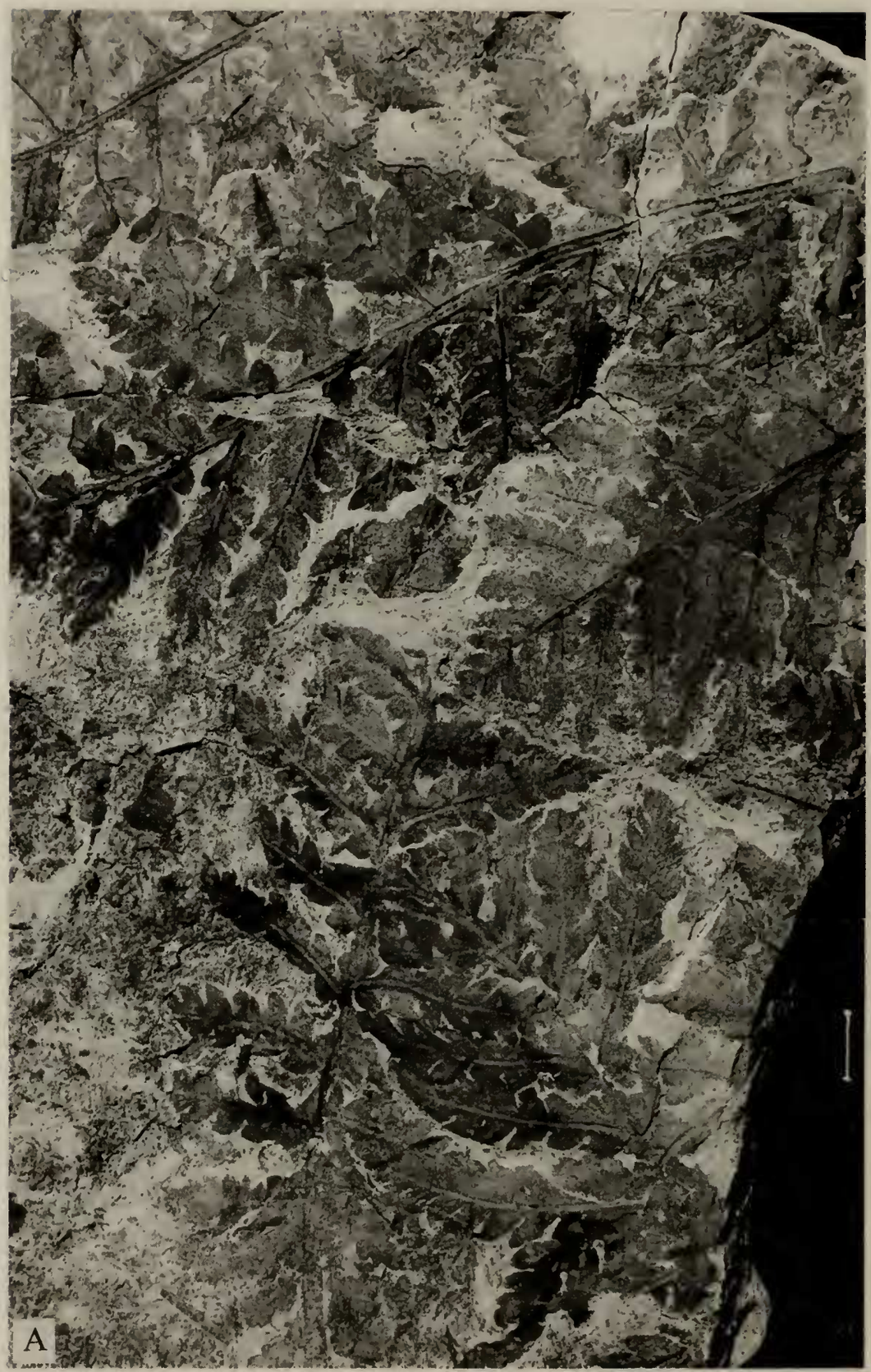


Figure 26. A. *Nymbopteron foleyi* Holmes gen. et sp. nov. AMF113538, holotype. Scale bar = 1 cm.

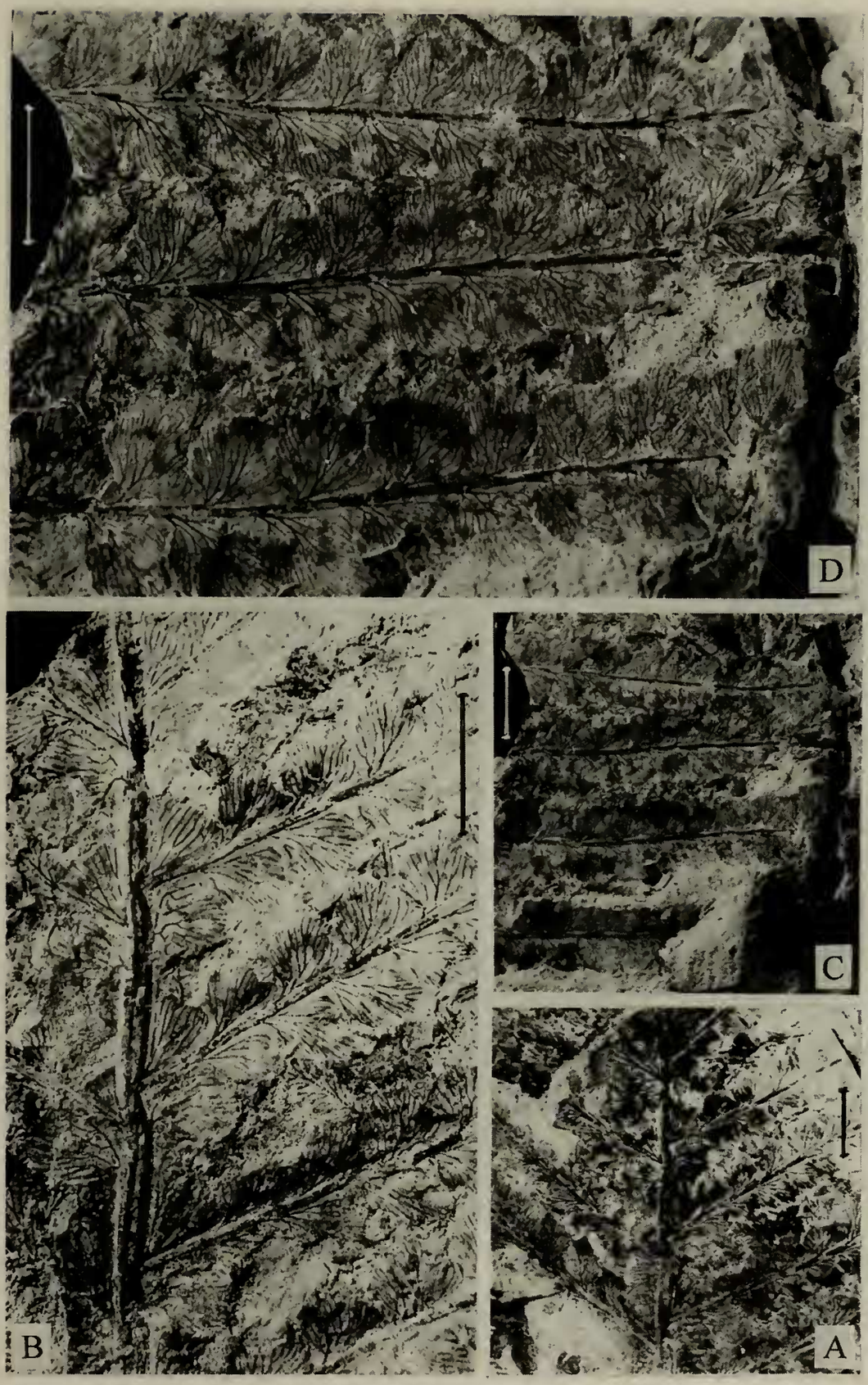


Figure 27. A–D. *Nymbopteron rhomboidale* Holmes gen. et sp. nov. All AMF113556; A. holotype, X1; B. X2; C. X1; D. X2. Scale bar = 1 cm.


Figure 28. A. *Nymbopteron uncinatum* Holmes gen. et sp. nov. AMF120968, holotype. Scale bar = 1 cm.

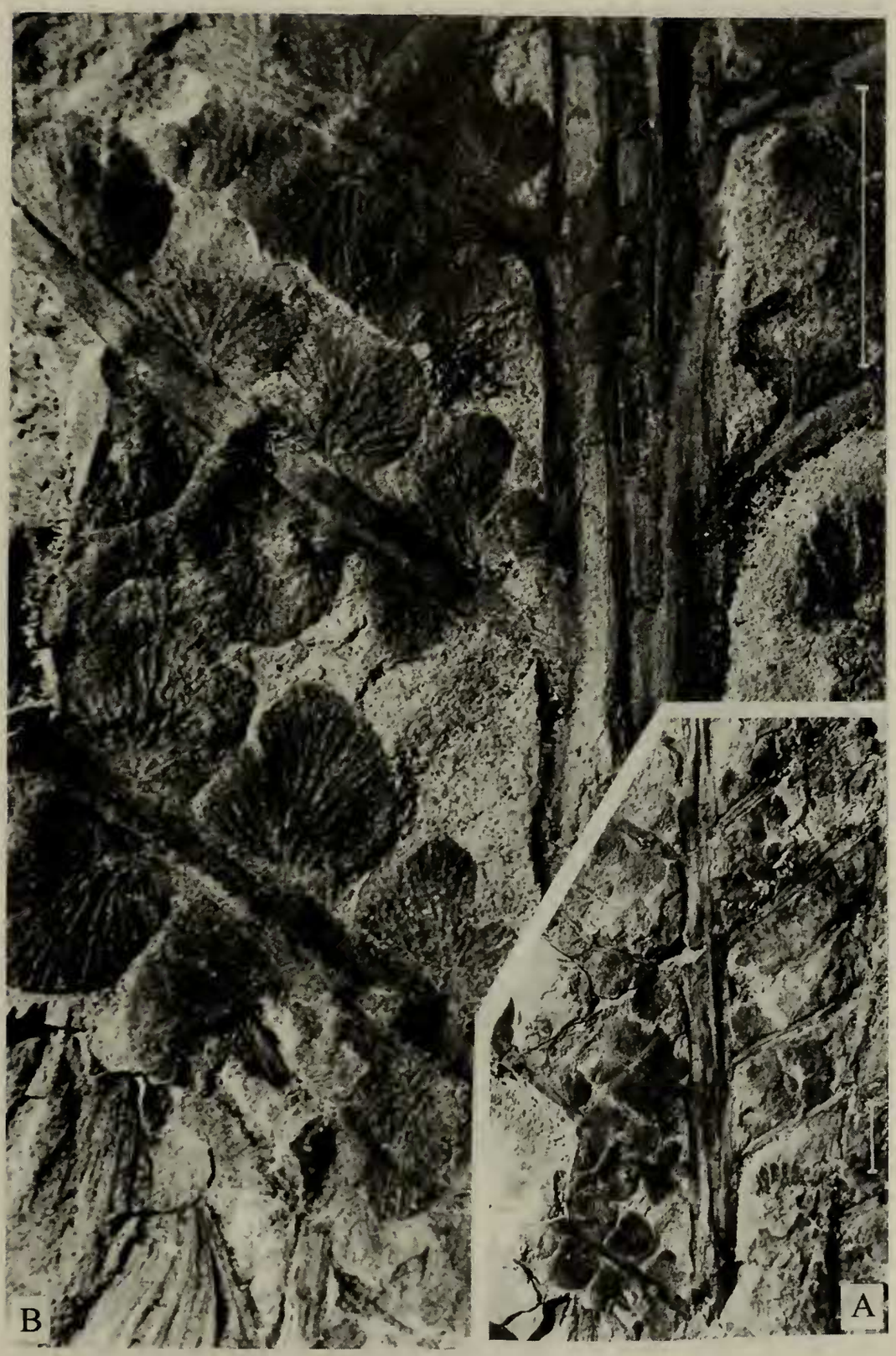


Figure 29. A, B. *Nymborhipteris radiata* Holmes gen. et sp. nov. A. AMF113489, holotype; B. AMF113489, X4. Scale bar = 1 cm.

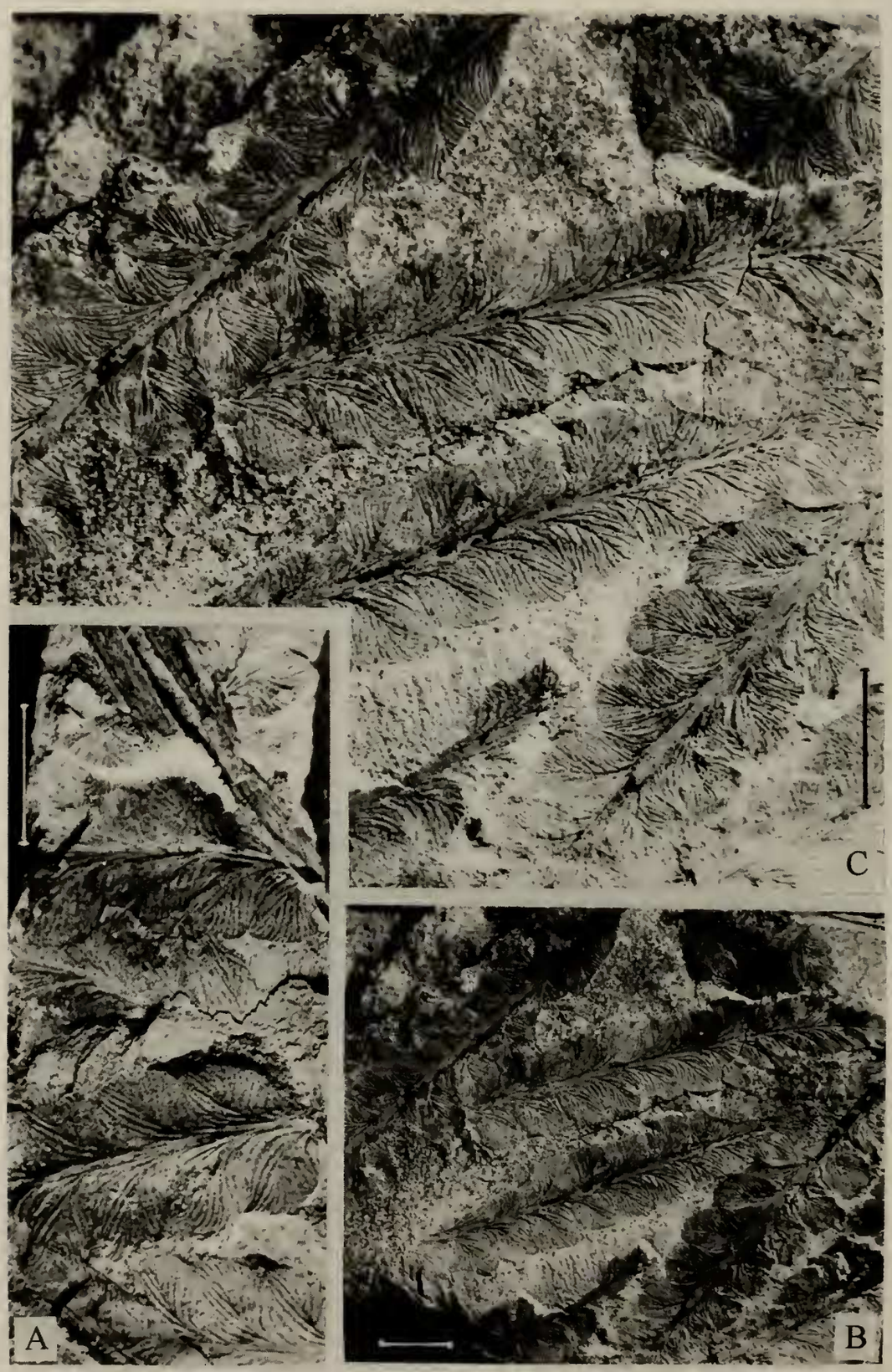


Figure 30. A–C. *Ptilotonymba curvinervia* Holmes gen. et sp. nov. A. AMF113480, holotype, X2; B. AMF113479; C. AMF113479, X2. Scale bar = 1 cm.


Figure 31. A. *Ptilotonymba curvinervia* Holmes gen. et sp. nov. AMF113483. Scale bar = 1 cm.


Figure 32. A–D. *Sphenopteris speciosa* Holmes sp. nov. A. AMF113520, holotype; B. AMF113520, X2; C. UNEF13557; D. AMF113521. Scale bar = 1 cm.

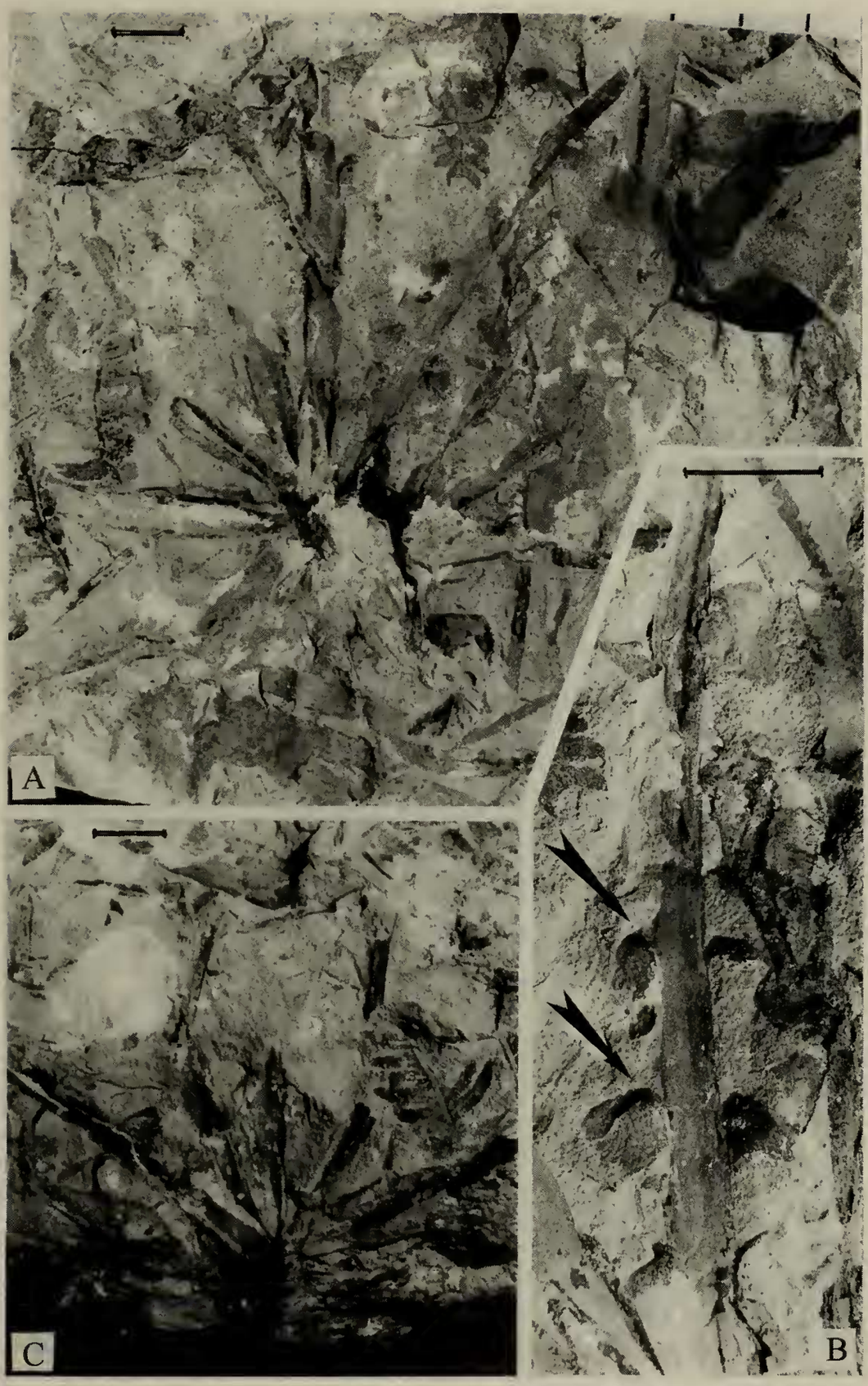


Figure 33. A–C. Fern bases. A. AMF113498; B. X2, pinnae arrowed; C. AMF113501, longitudinal section. Scale bar = 1 cm.

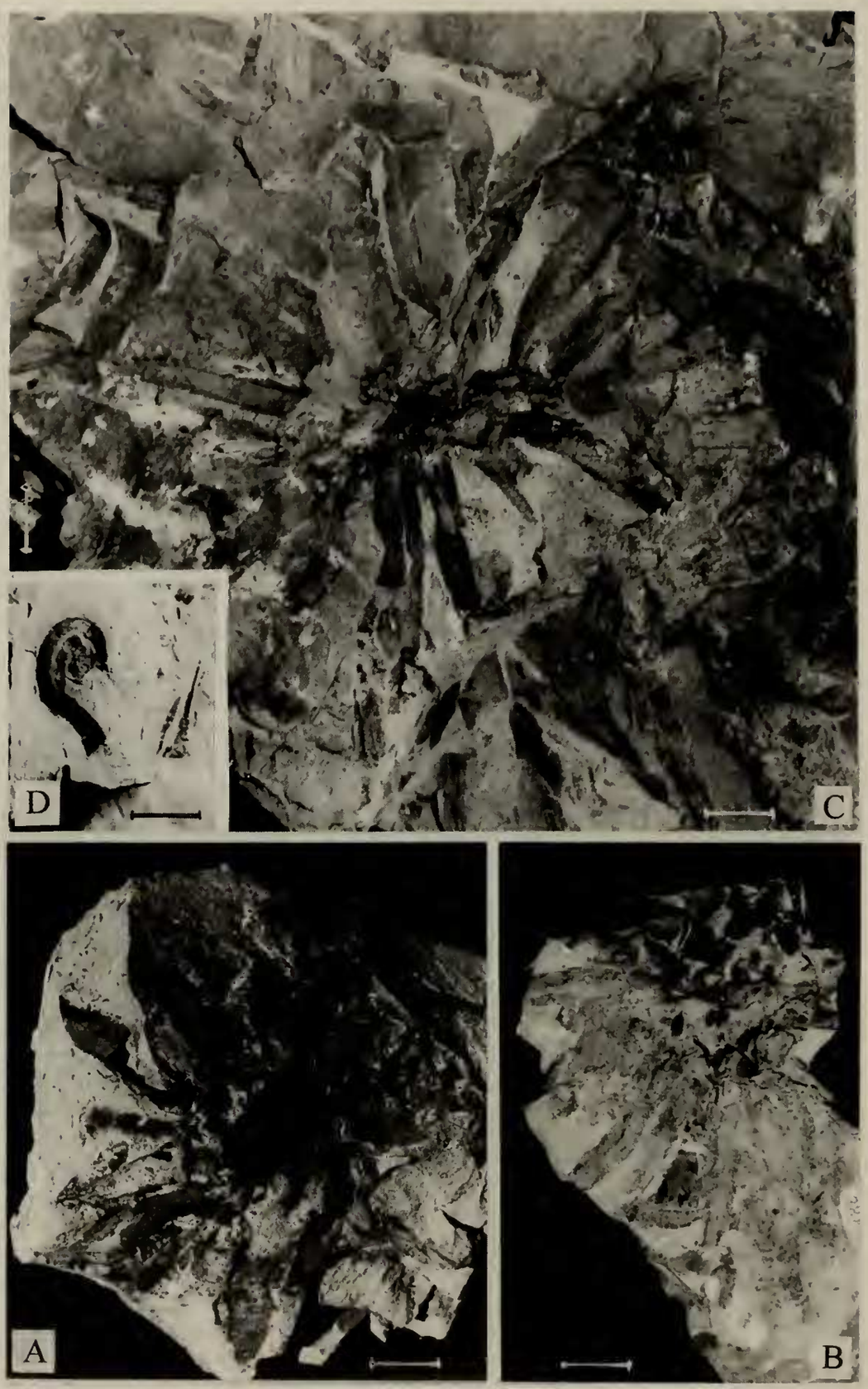


Figure 34. A–C. Fern bases. A. AMF113499; B. AMF113503; C. AMF113500; D. Circinate frond. AMF113519. Scale bar = 1 cm.